ROADS and STREETS

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Why Highway Transportation Should Not Be Controlled by the Interstate Commerce Commission

According to John J. Esch, a member of the Interstate Commerce Commission, "There is strong probability that the commission will take over the supervision of interstate motor bus and truck transportation." Heaven forbid.

Twenty years ago that commission "took over the supervision" of railway transportation, and for the first time in the history of American railroading there have been two decades of railway stagnation. When the commission blighting rule over railway rates went into effect, there was every prospect that most of the railways would be electrified in the near future, and that with electrification and growth of business there would follow a reduction of rates such as had characterized the prior history of railway transportation. But the streams of capital that had been flowing into railroad plants began to freeze up, and the "run off" that fed those streams was greatly reduced. Who wanted to invest money in a business that began to yield less than 6 per cent, when the average industrial enterprise was yielding 10 per cent.

As surely as anything can be inferred from facts in the world of economics, the regulation of railway rates by the Interstate Commerce Commission has throttled railway enterprise during the past 20 years. And now that commission wants to extend its beneficent activity to the field of highway transportation. It reminds one of the wish of the bolshevists to rule the world, because they have ruled so well in Russia.

Let us consider, for a moment, the fundamental reason for public regulation of rates or prices charged by a railway or a public utility. The reason is that railways and public utilities are regarded as monopolies whose charges would be exhorbitant if not controlled by the public. This being so, what becomes of the argument that bus and truck transportation rates should be controlled by a public commission? The fact is that instead of being monopolies these highway transportation agencies are among the most highly competitive in the world. In fact it is their effective competition with the railways that is causing railway managers to cry for protection against them. The railways are tied hand and foot by the I. C. C., and they justly complain of the helpless condition that they are in. But will the best answer to their complaint consist in hog-tying highway transportation also? We think not.

It has long been the fashion among railway and public utility managers to decry competition. Starting first with objections to the competition of agencies similar to their own, they have finally come to object to any sort of competition from any source. It was just this attitude in England that held back the development of the electric light because it competed with gas; that held back the telephone because it competed with the telegraph; that held back the trolley car because it competed with the bus.

The English are strong for vested rights, and any "right" that is first on the scene is, with them, "vested." Not so in America. We still believe in competition; and if "by their fruits ye shall know them," it seems clear that the American theory is best.

It is a severe test—the test of competition. It kills off more than it suffers to survive. It causes suffering during the weeding out process, when the losses often appear to exceed the gains. But in the long run it produces

economic gains far exceeding the losses. There is a cost of progress, and competition produces many such costs. But there is also a profit of progress, and here it is that competition excels.

The prevalent opinion that railways and public utilities should be protected against competition is not entirely sound. It has arisen from too close a scrutiny of the present added costs of competition, without an equally close scrutiny of the profits of competition viewed over a long period of time.

When street railway companies were crying for protection against "jitney bus" competition, they had it in their power to meet that competition successfully, if they only knew it. One utility manager, instead of joining the universal chorus for public protection, proceeded to protect himself. He built an entirely new type of street car, one that cut car-mile costs in two, because the car was made half as heavy and was operated by one man instead of by two—the now celebrated "one-man safety car." Then by doubling the number of cars, and thus giving the frequent service that the public was buying from the "jitneys," he began to win the battle. True, it was still one-sided but that was because the same fare for any length of haul was charged, which is economically unsound. Taking advantage of its unsoundness, the jitneys confined their work to the short haul transportation, thus skimming the cream. But this could have been met by zone rates, which doubtless would have been the next step had not most cities come to the rescue of the trolley companies by excluding the "jitneys."

Yet look at the result. Jitney competition brought about the only great economic improvement in trolley car transportation that has occurred in fifteen years. Still we are told that competition is a bad thing for utility companies and railways. And the sad thing is that those who tell us so firmly believe that they are right.

Unlimited competition is economically unsound. This is now universally granted. But unlimited monopoly is even more unsound. There is, without doubt, an economic mean between these two extremes, and it should be the business of economists to find this economic mean.

W. P. Gillette

Penn State to Test Frozen Concrete.—Pennsylvania State College is planning to conduct an experiment this fall and winter on the effect of frost on concrete, the coarse aggregate used to be a good quality local sand stone.

Increasing Stability of Asphalt Pavements

To the Editor:

The formation of waves in some of our asphalt pavements not properly designed for the heavy intensive traffic they are now carrying has during the past few years directed engineering attention to means of increasing the resistance of hot mix pavements to displacement. Excellent progress has been made in this direction but the writer feels that a note of warning should be sounded in connection with certain trends of practice which, while undoubtedly increasing stability, will if carried to extremes, result in the production of pavements which are more apt to crack in cold weather due to contraction.

It has been definitely established that increasing the percentage of filler, decreasing the percentage of asphalt and hardening the asphalt will produce a more stable pavement than has frequently been laid in past years but we have not as yet determined just how far we should proceed along these individual lines.

During the past two years the Asphalt Association has developed a test for measuring stability of fine aggregate asphalt paving mixtures but the evaluation of this test in terms of service results has not as yet been completed. The test shows the relative stabilizing effect of all of the factors above mentioned and indicates that increase in percentage of filler is perhaps the most effective. At the present time data are being assembled in connection with the stability of pavements of known history subjected to various climatic and traffic conditions and it is hoped that in the near future the influence of these factors will be properly evaluated both with relation to stability at high temperatures and resistance to cracking at low temperatures.

Until this work is further advanced the writer feels that it is particularly dangerous to proceed to extremes in hardening the asphalt cement or in greatly reducing its percentage in the paving mixture, as it is believed that longest serviceable life and greatest resistance to cracking will be obtained from mixtures carrying the largest percentage of a moderately soft asphalt which will produce the degree of stability required by the traffic and climate which it will have to meet. It is therefore urged that engineers proceed cautiously in modification of their customary practice, particularly along these lines.

PREVOST HUBBARD,
Chemical Engineer,
The Asphalt Association, New York City.

Meeting of Am. Soc. M. I. and Asphalt Association

An important gathering of municipal officials and asphalt contractors, producers, engineers and chemists of the United States and Canada is scheduled for Washington, D. C., Nov. 8 to 12 next, under the joint auspices of the American Society for Municipal Improvements, The Asphalt Association and the Association of Asphalt Technologists. Both separate and joint sessions will be held at various times during the week, the object being to discuss for mutual benefit a program of municipal improvements, particularly in the matter of street and highway construction. All kinds of municipal problems will be considered but emphasis will be laid on street planning, design, specifications, types of paving and methods of construction, location, contract lettings, excavating, opening and replacing pavements, street lighting, street and paving plant inspection, paving plant operation, paving methods between car tracks, street cleaning, snow removal and traffic regulation. Representatives of The Asphalt Association attending the Fifth Annual Asphalt Paving Conference to be held at the same time and place, together with representatives of the American Society for Municipal Improvements, will have places on the program of the joint sessions, as well as the sessions that will be held separately. All of the sessions, joint and separate, will be held at the Mayflower Hotel.

Separately, the American Society for Municipal Improvements will discuss such subjects as sewerage and sanitation, water supply, garbage disposal, public safety, city planning, municipal legislation and finance and miscellaneous subjects. The Asphalt Paving Conference will discuss such subjects as "A Service Study of Asphalt Pavements," "Adaptation of City Pavements to Country Highways," "Causes of Success and Failure of Bituminous Macadam," "Cold Patch and Cold Application in Pavement Upkeep," "Use of Soft Asphalt Cements for Surface Treatment," "Economic Selection and Use of Equipment," "Asphalt Contractors' Problems," and similar subjects. Stress will be laid on the matter of salvaging old macadam and gravel roads with asphalt. In addition to its individual sessions the Asphalt Paving Conference will meet jointly with the Association of Asphalt Technologists for a discussion of the technical and research problems of asphalt streets and roads.

At the joint sessions of The Asphalt Paving Conference and the American Society for Municipal Improvements, subjects of particular mutual interest will be discussed such as "Construction Details Essential to Effective Hot Mix Pavements," "Black Base and Its Place in Standard Specifications," and "The Economics of Salvaging Old Pavements."

Col. R. Keith Compton of Richmond, Va., is chairman of the Engineers' Committee, and J. H. Cranford of Washington, D. C., is chairman of the Contractors' Committee acting with C. G. Sheffield, president, and J. E. Pennybacker, general manager of The Asphalt Association, respectively, in arranging for the Fifth Asphalt Paving Conference and the joint sessions with the meetings of the American Society for Municipal Improvements are in the hands of the president of that organization, T. C. Hatton, Chief Engineer of Milwaukee, and its Secretary, C. W. S. Sammelman of St. Louis, acting with a special program committee. The joint sessions are being arranged by all the committees working together.

Among those who have already accepted places on the programs are A. H. Blanchard, professor of highway engineering, University of Michigan; R. H. Simpson, chief engineer, Department of Public Service, Columbus, Ohio; Dr. E. L. Butterfield, chemist, Borough of Queens, New York; Hugh W. Skidmore, president, Chicago Paving Laboratory; Col. R. Keith Compton, director of public works, Richmond, Virginia; G. H. Henderson, chief engineer, State Board of Public Roads, Providence, Rhode Island, and Francis P. Smith, consulting engineer, New York.

Entertainment features will include the annual banquet of the American Society for Municipal Improvements, in which the delegates to the other meetings will join; a golf tournament at the Congressional County Club; a tea, card party, theatre party and dance for delegates and their ladies; a boat trip down the Potomac to Mt. Vernon and return with luncheon, music and dancing, and an inspection trip through the streets of Washington and its environs.

Annual Convention of Canadian Good Roads Association.—The 13th annual convention of Canadian Good Roads Association will be held in Edmonton, Alberta, Sept. 28 to 30, inclusive. Each Provincial government will be represented. The officers of the association are: J. L. Perron, Minister of Roads, Province of Quebec, Hon. Past President; P. J. Veniot, ex-Premier, Province of New Brunswick, Honorary President; W. R. Clubb, Minister of Public Works, Manitoba, President; George S. Henry, Minister of Highways, Ontario, 1st Vice President; John Oliver, Premier, British Columbia, 2nd Vice President; George A. McNamee, Montreal, Secretary-Treasurer. The Executive Committee includes S. L. Squire, Chairman; J. L. Perron, J. A. Duchastel, P. J. Veniot, A. McGillivray, Wm. Findlay and George A. Mcnamme.

Road Crust Strengthening

Method Developed in Los Angeles County, California

A method of strengthening earth road crusts that is receiving considerable attention at the present time by the road department of Los Angeles County, California, and other road departments on the West Coast consists of rolling lightly a 1-stone thick layer of large crushed rock into the earth. The method was perfected by E. A. Burt, Construction Engineer of the Los Angeles County Road Department from his studies of the low cost thin macadam road crust for residential streets and light traffic roads.

Method of Construction.—We are indebted to F. N. Joyner, Consulting Highway Engineer, Los Angeles County, for the following details:

In the Burt method, as well as in all good methods of road building, the first essential is the proper constructing, shaping and consolidating of the earth on which the completed road crust is to lie. This being done, there is then carefully spread or placed on the earth a 1-stone thick layer of large crushed stone, size of fragments to be from 2½ in. to 3½ in. in longest dimension and commonly designated as No. 1 stone, care being taken to see that each and every stone fragment rests upon the earth and touches other fragments on all sides. This exact spreading requirement may seem rather hard and costly to fulfill, but practice has shown that men learning the spreading quickly and spread the stone at the common ton price for thin butter macadam. Spreading of the stone for the Burt method was recently done by a mechanical spreader, on Washington St., East Pasadena, that was so near correct as to require very little hand work behind the spreader. Following the correct spreading or placing of the crushed stone, watering of the road is done sufficiently to slightly soften the underlying earth, and as different earths will take different amounts of water, the proper quantity to spread must be carefully watched. Rolling of the stone comes next. But now the roller is not used to bind the stone fragments together as is done in macadam construction, the roller being run to only press stone into the moistened earth, bring the earth up through the openings between the irregular stone fragments to the same surface as the stone.

The rolling operation completes the Burt method, and the roadway is now ready to be used either as a good subgrade on which to lay a standard pavement or as a bottom course for a light macadam. If only a light macadam is needed an application of a ½ gal. of heavy asphaleic oil covered with the proper amount of stone screenings gives a road crust that has carried the fairly heavy traffic on East Washington St., Pasadena, for about a year without any indication or failure or weakness.

Costs.—Mr. Burt has kindly furnished us with the following average figures for a series of very similar jobs of laying this surface:

			Per Sq. Yd.
.14 Tons rock per sq. yd.	@	$1.75	$2.45
1 Gal. asphaltic oil per sq. yd.	@	.07	07
Excavation and preparation of subgrade			.135
Labor and equipment laying pavement			.135
Total			$.585
Total per sq. ft.			.065

Endurance Tests of Tires

For the past 2½ years the U. S. Bureau of Standards has been making endurance tests of various brands and types of tires. This work is described in Technologic Paper No. 318, which was released last July, and which can be obtained from the Superintendent of Documents, Washington, D. C., at 10 cents a copy. The paper gives test results on 230 cord tires of the 3½, 4, 4½, and 5-in. sizes, and of 36 brands. The data was presented in graphical form. The various brands are identified by letters; manufacturers' names are not given.

The August Technical News Bulletin of the Bureau of Standards states that following conclusions have been reached as to factors which influence the life of tires:

1. A carcass in which the friction rubber is slightly compounded appears to stand up better under test than one in which "pure gum" is used.

2. Within the customary limits of air pressure used in tires, the higher the pressure the better the tire will stand up.

3. Fabric tires develop a much higher temperature than cord tires, and their life is much less than cord tires.

4. Separation, which was the principal cause of failure in these tests, did not always take place in the same location in the tire. It occurred in most cases between the tread and breaker, breaker and cushion, cushion and carcass, or between the outer two plies.

5. Any particular brand of tire usually showed a characteristic type of failure.

6. Some makes of tires "blow out" much sooner after separation has started than others.

7. Compounded inner tubes for truck tires appear to withstand the action of heat better than those of the "pure gum" type.

The paper points out that no more than one-half of all the tires tested passed the requirements decided on as reasonable performance for a high-grade tire. However, during the period of the tests, a considerable improvement in performance was noted in the case of some makes.

The two types of testing machines developed by the bureau are described and illustrated and the test conditions are fully set forth.

Finishing Widened Curves

New Method of Using a Finishing Machine

How to use a finishing machine on super-elevated and widened curves has always been considered more or less of a problem, particularly where the crown of the road was flattened on the curve.

The method generally used in the past has been to finish around the curve for the width of the machine, which was carried on a false form, and then complete the widened portion by hand. However, considerable hand finishing was required for that portion of the slab not spanned by the machine. Furthermore, where the crown was changed from normal on tangents, to nothing on curves, a further complication was added.

To overcome these difficulties, and obtain

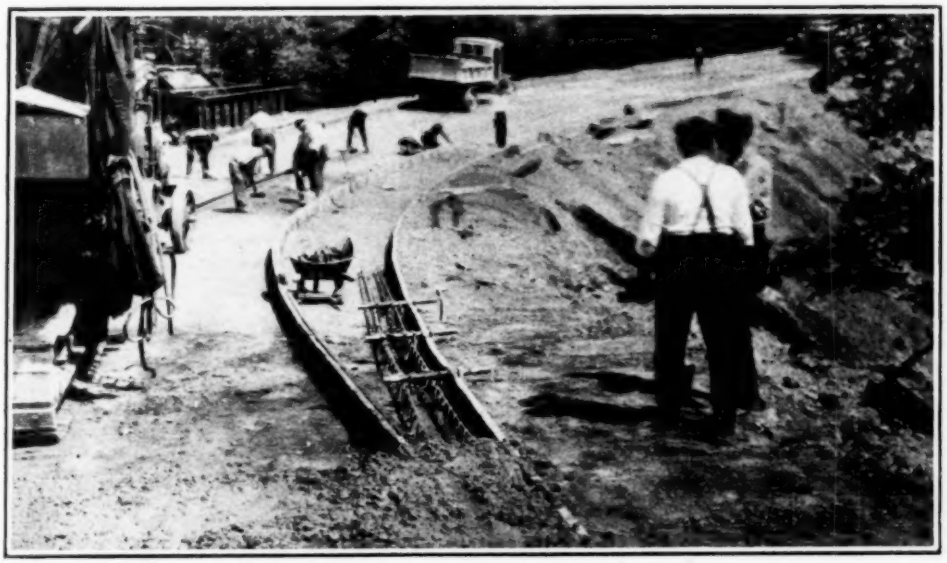


Fig. 1—False Forms in Place

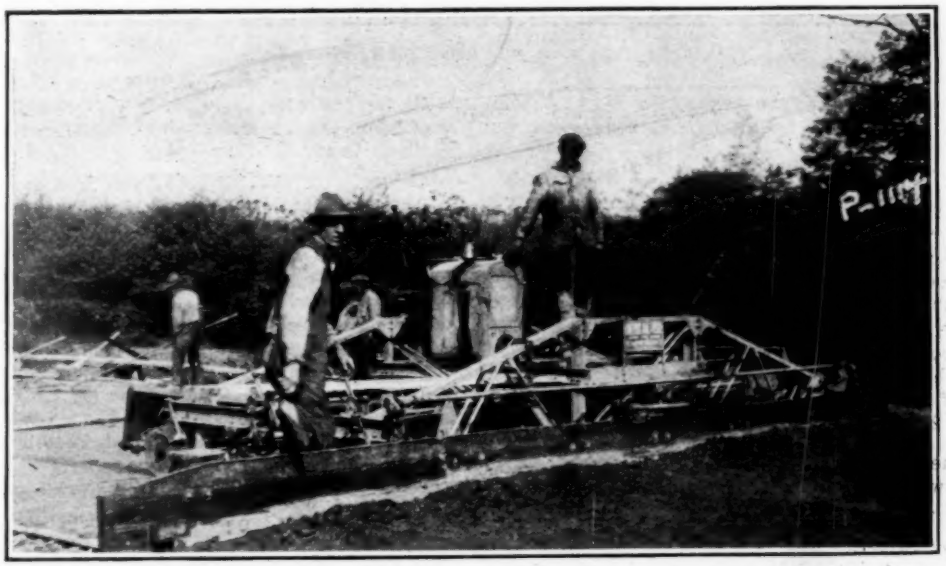


Fig. 2—Extra Screed Board in Operation

the same results from the finisher on widened curves as on straightaway sections, a Pennsylvania contractor, McPherson Brothers, of Edgeworth, Pa., with the co-operation of the Pittsburgh District office of The Lakewood Engineering Co., developed a new method of handling such work, which has made it easy to obtain a flat crown, and to finish the entire width of the slab on a curve at one operation with the machine.

Briefly, the method utilizes an extra screed member for the finisher, long enough to span the slab at the widest portion of the curve.

To carry the machine around the curve, a false form was set as shown in Fig. 1. This consisted of two 2 x 8 timbers spiked together.

Concrete was deposited for the full width of the slab.

The regular screed member of standard width and crown was removed from the machine, and replaced with a special screed member 6 ft. longer than the regular screed. This extra member could be attached to the finisher so as to put the additional length on either side of the machine, to take care of reverse curves. Furthermore, the extra screed board was set for flat crown. It is shown in operation by Fig. 2.

The time required to change from the standard width to the extra width screed member was less than half an hour.

The advantages of using such a screed member for finishing curves are obvious. The entire width of slab could be finished by the machine, and the change from a crown surface to a flat slab was automatically accomplished.

The false form which carried the machine around the curve, of course, was pulled behind the finisher, as shown in Fig. 3; the void left in the concrete was filled by hand.

The particular job on which this method originated was located in Allegheny County, near Pittsburgh, Pa. A number of grades were encountered, some of which were as much as 10 per cent. In places the road was a succession of widened, super-elevated curves, with flat crown. In addition, slag concrete was being used, and often the "slump" was as little as ½ in.

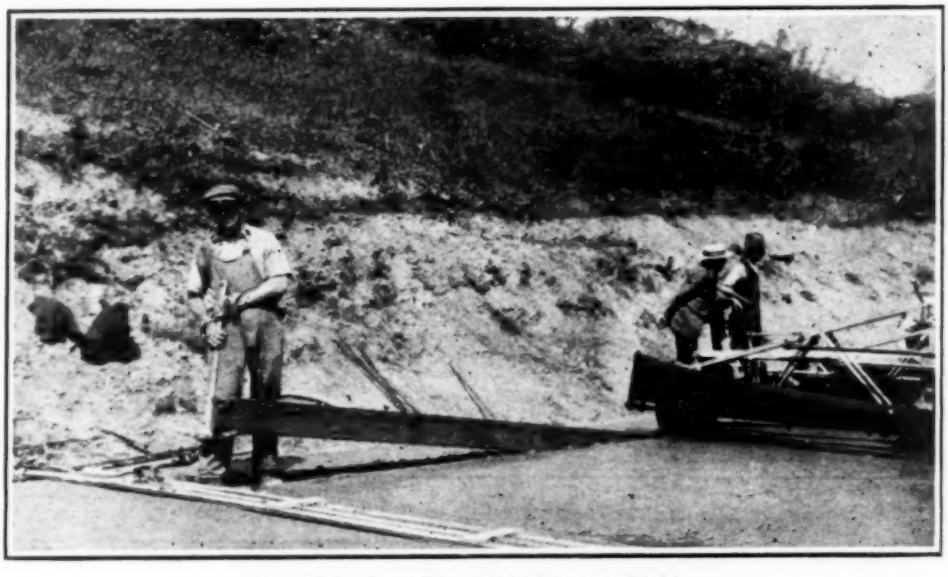


Fig. 3—False Form Was Pulled Behind the Finisher

Aerial Photography Used in Plea for Road Relocation.—In order to get facts to present to the state highway commission to show the desirability of relocating a road to eliminate three overhead bridges residents of a Wisconsin village hired a photographic airplane and had the entire distance to be changed photographed from the air and made into a mosaic map. Two strips, side by side, one showing the present route and one the proposed route, were photographed, requiring 65 photos, each about 8 in. square.

Street Traffic Research Bureau at Los Angeles.—A bureau of street traffic research has been established by Los Angeles, Calif. Dr. Miller McClintock is director.

Roadside Development

What Is Being Done in Wayne County, Michigan, Outlined in 19th Annual Report (1924-25) of County Road Commission

The development during the past year of this phase of road improvement has brought out convincing results. The first planting of three years ago is beginning to bear out the future appearance of the roadsides.

Within the short space of a few years, the planted highways will become country drives comparable only to the finest boulevards, and to those who give this matter a second thought, the present accomplishments stand out in vivid contrast to the barren, treeless stretches of county roads which existed only a short time ago.

To date over 17,000 trees have been planted, covering more than 135 miles of improved county roads. A total of 7500 shrubs have been planted at various intersections, where small triangular parks have been constructed. Trimming has been completed at all dangerous intersections, railroad crossings, and along more than 60 miles of road.

All planted trees and shrubs have been sprayed both with dormant and summer spray. A total of 31,000 sq. yds. of sod have been placed on slopes at grade separations, bridges, and through various heavy cuts and fills.

As in the past, all public utility companies are continuing to co-operate with us in placing poles to avoid trees, and in trimming for the maintenance and construction of their lines. All jobs covered by permits have had our usual thorough inspection.

Producing well-kept, proper-appearing roadsides, and providing for the comfort, safety, and convenience of the traveling public, constitute the final improvements necessary for perfect road maintenance.

Highway Planting. — Approximately 7000 trees were planted during the past year, covering 58 miles of county roads. In addition to this, all dead trees were replaced in plantings previously made.

The usual standard of high quality and dependable trees were planted, including Red Oaks, Pin Oaks, American Elms, Sugar, and Norway Maples. Special attention was given to soil requirements, drainage, landscape considerations, and location with reference to traffic. The size of trees planted averaged 2¾ in. in diameter. The commission has found that a tree of this size is the most economical to plant, and that considerable shade is produced in a remarkably short time.

The usual maintenance of trees has continued. Each tree is cultivated continually during the summer months, and spraying, mulching, trimming for form is practiced at the proper times during the year. The total loss of trees planted has not exceeded 10 per cent, proving the worth of systematic and continuous maintenance.

It is planned in the future to continue the highway planting until every improved road is lined with trees, and replacements will be made from year to year as needed.

Trimming.—Rapid and efficient work has been produced by the trimming crews during the past year. Their years of experience and training have resulted in completed jobs of first quality. The larger part of last year's work consisted of obtaining proper clearance on new roads, intersections, and railroad crossings, and clearing away results of storm damage. Regular trimming, practical repair work and emergency trimming such as mentioned above will be continued in the future.

Spraying.—All young trees, planted by the board, are sprayed twice each year. One application is for leaf-eating insects and the other is for scale insects. By taking this precaution, it is practically impossible for an outbreak to occur which would cause serious damage. As a result of this, all the trees are kept in a continuous healthy and thrifty condition. This program will be carried out from year to year, with special attention given to unusual situations.

Road Intersections.—More than 6,500 shrubs were planted last year to improve the appearance of parkways and road intersections. Approximately 6 acres of this ground was also seeded. It has been found that a mixture of one-third each of Kentucky blue grass, red top, and white clover seed makes the best combination of grass seed for average use. This mixture is varied, according to the type of soil encountered. In all these locations the grass is kept mowed, and the shrubs cultivated, sprayed, mulched, and watered. These small parks are useful as well as being a pleasant addition to the landscape, in that they afford a place for the motorists to stop, lunch, change tires, rest, etc.

Roadside Comfort Stations.—Last fall, two roadside comfort stations were completed, their locations being on the Five Mile Road at Phoenix Park and on the Willow Road at Huron River Park.

Only a few weeks ago, two more of these buildings were completed, one at the junction of Huron River Drive, Belleville and Sumpter Roads, and one at the junction of Telegraph and the Redford-Dearborn Town Line Road.

These buildings are constructed of stone and brick, and are practically fireproof. Nothing has been spared to give the public every form of modern convenience. Each structure is equipped with a separate compartment for

men and women, with an additional room for shelter and information.

The last two buildings constructed have a special ladies' rest room which is comfortably furnished. In each case, electric lights, public telephone, steam heat, and both hot and cold running water have been installed. The water in each building is tested each week by the Detroit Department of Health.

Thousands of people, including visitors from many foreign countries, have entered their names in the guest books of these various comfort stations. Innumerable requests for additional buildings, and favorable comments regarding those already completed, convince us that they are really a necessity. In view of this increased demand, it is planned to continue the construction of these comfort centers at locations where they will best serve the greatest number of people.

Sodding.—More than 16,000 sq. yds. of sod have been laid since Sept. 1, 1924. This work, being inexpensive to perform, has resulted in the saving of thousands of dollars which might have been otherwise spent in maintaining banks against washouts. In addition to this it gives bridges and grade separations a distinctive natural setting immediately on completion of the work. All sodded slopes are kept closely trimmed, producing a perpetual neat appearance. It is intended to continue sodding in the future on all grade separations, bridges and other places where necessary.

Concrete Open to Traffic in 4 Days

High Early Strength Pavement Described in August Concrete Highway Magazine

Opening a concrete pavement in four days' time to the heavy traffic at Grand Ave. and Dearborn St., Chicago, and securing a compressive strength of 2,350 lb. per square inch at the end of three days has aroused much interest among contractors and engineers.

This concrete pavement fronts two sides of the new building of the Portland Cement Association and the alley back of it. Heavy new equipment for the Research Laboratory was being moved in, making it desirable that the pavement be opened to use with the least delay. This was especially true of the alley which was opened at the end of the third day.

To meet the needs of this particular job, a mix was designed in the Portland Cement Association Research Laboratory, which could be opened to traffic in 3 days. The proportions were 1 part cement, 1.6 parts sand, 2.1 parts coarse aggregate and 5 gal. of water per sack of cement. No admixtures or accelerators were used. Ordinary paving materials in the contractor's storage yard were used, consisting of a well graded coarse sand, pebbles ranging from ¼ in. to 2 in. in size and crushed granite ranging from ½ in. to 1½ in. in size. Standard portland cement from the contractor's stock was used.

Dry batches of cement, sand and stone were hauled by motor truck from the material yard about ten miles away. Seventeen trucks were employed and although traveling through heavy city traffic, no delays occurred.

Each batch was mixed 1½ minutes after all ingredients were in the mixer drum. The rich mixture proved very readily workable considering the limited amount of mixing water. It stiffened up quite rapidly and the finishers found it necessary to work directly back of the mixer.

The pavement was sprinkled as soon as it was possible to do so without marring the surface. This was kept up at intervals during the first three days. It was intended to open the pavement to traffic in three days, but delay in repairing the edge of the adjacent old asphalt pavement kept it closed until the morning of the fourth day after completion. The alley, however, was opened to traffic at the end of the third day.

The pavement, including the alley, is 10 in. uniform thickness. Granite aggregate was used for the upper 3 in. On Dearborn St. the pavement is 30 ft. wide from the curb to the center of the street. This was placed in two 15-ft. strips, separated by a concealed longitudinal metal joint. Transverse moulded expansion joints ⅜ in. wide were spaced at 30-ft. intervals. The edges of the slabs all the way around, including transverse joints, were tooled with an edger. The concrete over the dividing plate on Dearborn St. was opened with a sharp edge trowel after finishing and the surface was tooled directly above the plate. This will prevent the fine, slightly irregular crack in the surface which otherwise appears above such a division.

Several 6x12-in. test cylinders were taken from the concrete after dumping and stored while hardening on the roof of the Association building. The average compressive strength of these cylinders were as follows:

	Lb. per sq. in.
At 30 hours	1,330
At 2 days	1,860
At 3 days	2,350
At 7 days	3,100
At 28 days	4,720

Through the courtesy and cooperation of the Chicago Board of Local Improvements, J. J. Sloan, President, and the Bureau of Streets, this work was done by private contract. The contractor was the Marquette Construction Co., of Chicago, of which John O'Gara is president.

Asphalt Paving Mixtures

Results of a Study of Factors Affecting Their Stability Given in Paper Presented at Last Annual Meeting of American Society for Testing Materials

By PREVOST HUBBARD and F. C. FIELD

Chemical Engineer and Chemist, The Asphalt Association, New York City

At the 1925 annual meeting of this society the authors presented a paper* describing a laboratory test for determining the relative stability, or resistance to displacement, of paving mixtures of the sheet asphalt type. Briefly described, this test consists in forming a cylindrical briquette from the hot paving mixture, allowing it to cool and age for a short period, then warming it to 140° F., placing it in a testing mold and measuring the maximum load required to force the mixture through a circular orifice of given diameter. Such load is recorded as the stability value of the mixture.

Asphalt paving mixtures of this type which are composed of sand, mineral dust and asphalt cement, are plastic bodies meeting Bingham's definition† of a plastic solid which is as follows: "A plastic solid is made up of particles which touch each other at certain points. The spaces between these particles may be empty or may be filled with gas, liquid or amorphous solid." Bingham defines plasticity as "a property of solids in virtue of which they hold their shape permanently under the action of small shearing stresses but they are readily deformed, worked or molded under somewhat larger stresses." He further calls attention to the fact that plasticity is a complex property made up of two independent factors, internal friction and mobility and that in plastic flow it is generally understood that a definite shearing force is required before any deformation takes place.

Density Important Factor in Stability.—In the test devised by the authors measurement is made of the initial resistance of the mixture to shear, or of its initial internal friction, and not of its mobility or plastic flow. Other things being equal, it is evident that this initial internal friction will depend to a great extent upon the closeness of packing of the mineral particles. In other words, degree of compression or density is a most important factor bearing upon the stability of any given mixture and this was clearly indicated in a series of tests by the authors on briquettes of the same mixture formed under direct pressures of 1,000, 2,000 and 3,000 lb. per sq. in., where it was found that, within this range, the stability value of the mixture varied directly with the forming load. Of course such relation would not continue to hold indefinitely with increase in pressure, as a point would finally be reached where no greater density could be secured without crushing the individual grains of the mineral aggregate. Such a point may be termed maximum practical density.

Direct compression under 3,000 lb. per sq. in. had originally been selected as a basis for comparing stability values but it was later noted that under this load many mixtures did not develop the density that they might reasonably be expected to possess and this fact has led to a modification of the original method of preparing specimens. This modified method, wrich is briefly described in the following paragraph has, in general, raised the stability value of all mixtures tested but where checks have been run the trend of new results is practically the same as for the old results and the differences are for the most part purely relative.

New Method of Forming Test Specimens.—The following directions cover the new method of preparing test specimens in batches of three, each batch weighing approximately 350 grams.

"Weigh out the dried sand and filler to C. lg. Heat this aggregate in the tared mixing dish to 350° F., place on balance and weigh in hot asphalt at 350° F. to O. lg. Thoroughly mix the contents of the dish for 5 minutes with a 1 in. putty knife, then place approximately 100 grams in each of three forming molds, numbered 1, 2 and 3, preheated to 250° F. Place the molds with base plates on a hot plate and bring the contents of No. 1 mold to 275° F. as determined by a thermometer which is used for stirring the mixtures. Remove mold No. 1 from hot plate and tamp contents for ½ minute with a ¾ in. diameter round iron rod 8 in. long. Then insert the plunger and place the mold in the empty water bather on base of compression machine. Apply pressure to the top of plunger until a load of 3,000 lb. per sq. in. is reached. Fill the bath with cold water to a depth of 3 in. and allow the briquette to cool under pressure for

*A Practical Method for Determining the Relative Stability of Fine Aggregate Asphalt Paving Mixtures, Proc. A. S. T. M. 1925 Vol. 25 pps.

†Fluidity and Plasticity by Eugene C. Bingham, McGraw Hill Book Co.

5 minutes. Then release pressure, remove the mold from the bath and force out the briquette. While the first briquette is under pressure bring the contents of No. 2 mold to 275° F. Tamp, compress and cool the mixture as in the case of No. 1. Repeat the operation with No. 3 mold. Keep the hot plate so regulated that until the mixtures are to be brought to the temperature for tamping they are maintained at about 170° to 180° F."

The compressed briquettes should measure approximately 1 in. in height. After removing from the mold they are allowed to age in air overnight and then placed in a hot water bath accurately maintained at the temperature of test (usually 140° F.) for not less than one hour before testing.

Table I.

Physical Characteristics Sand & Filler		
Determination	Crane Sand (3)	Limestone Filler (2)
Seives 10-20	2.5 %	
" 20-30	7.4 "	
" 30-40	11.5 "	
" 40-50	20.2 "	.2%
" 50-80	36.2 "	.5 "
" 80-100	12.0 "	1.9 "
" 100-200	9.4 "	25.5 "
" 200-250	.8 "	5.3 "
" 250-300		1.6 "
" 300-350		9.4 "
Pass 350		55.6
Total	100.0%	100.0%
Specific Gravity	2.64	2.69
Percent Voids	38.8%	29.0%

The new method of forming specimen has improved the accuracy of the test but occasional erratic results on briquettes of the same mixture and of practically the same density have led the authors to believe that lack of uniform density throughout the individual test specimen may sometimes occur and that the method may eventually be further improved so as to insure maximum practical density throughout the entire briquette.

Effect of Mineral Fillers on Stability.—In the paper last year the authors showed by diagrams that the addition of increasing amounts of mineral filler to a given sand in general increased the stability of certain asphalt paving mixtures and that different fillers developed different stability values in the mix when present in the same percentage by weight. Thus a mixture containing 10 per cent of hydrated lime showed a stability value about equal to one containing 20 per cent of limestone dust and about one and one-half times as great as a mixture containing 10 per cent of limestone dust.

In a later paper* the authors showed that when the per centage of asphalt in the mix is kept constant and mineral filler is added to a given sand in increasing amounts, a point may be reached where further addition of filler begins to lower the stability. From a series of mixtures containing varying percentages of the same constituents it was further shown, within certain limits that among compressed mixtures containing the same percentage of voids that mixture which showed the lowest percentage of asphalt developed the greatest stability. Typical curves were also shown illustrating the following. With a given mineral aggregate maximum stability is secured in mixtures carrying a rather limited range of percentage of asphalt. Increase in stability is to some extent controlled by increase in hardness of asphalt.

What the Present Study Covers.—So many factors bearing directly upon the stability of asphalt paving mixtures had been developed, that the authors realized that a large field must be thoroughly investigated before it would be possible to obtain a correct perspective of the whole and ascertain the true interrelationship of all of the factors. It was possible to start almost anywhere in mapping out this field and as the beginning of a systematic study it was decided to concentrate upon the effect upon stability of variations in characteristics and percentage of the asphalt cement. The results presented in this paper deal primarily with this phase of the investigation although it will be seen that most of the other factors already mentioned must be considered to some extent at the same time.

All of the mixtures hereafter described contained the same sand and limestone filler, possessing characteristics as shown in Table 1. The sand represents a product widely used in sheet asphalt construction in New York City and vicinity, while the limestone dust, although containing somewhat less material passing the 200-mesh sieve than desirable, is widely used in the same locality and was obtained from the plant of a large paving contractor.

The asphalt used in these tests were all produced from crude Mexican petroleum and possessed the physical characteristics shown in Table II. Samples Nos. 3, 4 and 5 were regular steam refined paving grades. Sample No. 7 was an asphalt cement produced by

*Researches on Asphalt Paving Mixtures Proc. A. S. T. M. 1925.

fluxing No. 5 with a heavy Mexican flux. Samples Nos. 1 and 2 were regular commercial grades of blown asphalt which were included in the tests for the purpose of ascertaining if low ductility of the bitumen had any direct influence upon the stability of paving mixtures in which they were incorporated.

Relation of Stability to Amount of Asphalt.—In studying the effect of these asphalts upon the stability of paving mixtures it was decided to use three mineral aggregates com-

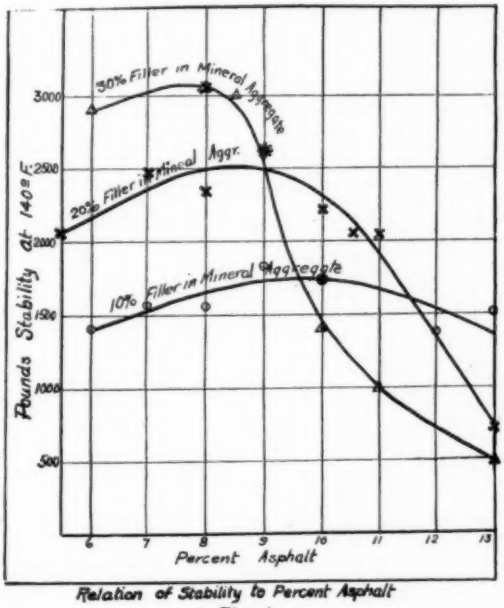
Table II.

Physical Characteristics of Asphalt							
Sample No.	Materials	Penetration 77°F.	Specific Gravity	Melting Point	Ductility 32°F.	Ductility 77°F.	Ductility 115°F.
1	Brick Filler	28	1.034	165°F.	1 Cm	93 Cm	20 Cm
2	Waterproofing Asphalt	35	1.04	152°F.	4 "	335 "	107 "
3	Paving Asphalt 31-40 Pen.	37	1.044	135°F.	1.5 "	103 "	130 "
4	Paving Asphalt 41-58 Pen.	48	1.041	133°F.	1.75 "	101 "	150+ "
5	Paving Asphalt 61-70 Pen.	66	1.034	125°F.	4.5 "	106 "	150+ "
7	Paving Asphalt Fluxed	106	1.035	113°F.	9.0 "	80 "	110 "

posed of sand and ten, twenty and thirty per cent of limestone dust respectively. Previous work had shown that stability was to a considlerable extent dependent upon the percentage of asphalt in the mixture so in order to select satisfactory mixtures for further comparison a series of tests was first run with mixtures composed of the three mineral aggregates and varying percentages of No. 4 asphalt. The results obtained are illustrated by the three curves in Fig. 1.

The relation between stability and percentage of asphalt for these three aggregates is exceedingly interesting and significant. In the first place it will be noted that in each case stability increases to a miximum with increase in asphalt from 6 per cent to a percentage which differs from the other two mixtures and then falls off as more asphalt is used. The stability represented at the crest of these curves is highest for the high filler mix and lowest for the low filler mix, but it is apparent that sensitiveness to slight changes in percentage of asphalt increases with increase in filler. In other words after maximum stability has been secured the high filler mixtures fall off much more rapidly with further increase in asphalt than do those containing less filler. The probable reasons for this will be discussed later as further data is presented. For the present it may be noted that as the amount of filler was increased from 10 to 30 per cent of the mineral aggregate, maximum stability was obtained by decreasing the percentage of asphalt in the mixture from 10 to 8 per cent. For this reason the mixture shown in Table III were selected for further study.

Effect of Voids in Aggregate.—At this point a slight digression may be helpful in analyzing the stability results so far presented and those which follow. A number of investigators have rather recently come to the conclusion that the percentage of voids in the mineral aggregate has a very direct bearing upon the amount of asphalt which can be successfully used in a given paving mixture. Various tests have been devised for determining voids in sheet asphalt aggregates, perhaps the most popular being methods in which the dry mineral aggreate is fed to refusal into a cone or cylinder of known capacity the container being tapper or rapped upon a table or assist close packing. Voids in the packed aggregate are then calculated from the weight of the known volume, taking into account the specific gravity of the solid aggregate. By standardizing all details of procedure reason-



Relation of Stability to Percent Asphalt

Fig. 1.

ably satisfactory check results may be obtained but the authors have felt that any method of packing a dry aggregate containing a high percentae of filler is likely to result in sereation to such an extent as to produce misleadin results.

As a means of obtaining some measure of voids in mineral aggregates as used in the stability test, a new method aimed to eliminate segregation as far as possible was therefore devised. Preliminary tests were first run on dry sand containing no filler and on dry limestone dust after which varying percentages of

kerosene were mixed with each until a range in proportion of kerosene was established which would give the same calculated voids as found in the dry aggregates. The following is a brief description of the method which was thus developed.

Place 100 grains .01 g. of dry mineral aggregate in a porcelain saucer weighing the sand and mineral filler separately in proper

Table III.

Mixtures Tested

Determination	Mix (1)	Mix (2)	Mix (3)
10-40 Mesh	17.0	15.0	14.0
40-80 "	46.0	41.0	37.0
80-200 "	20.0	21.0	21.0
Pass 200 -	7.0	14.0	20.0
Asphalt	10.0	9.0	8.0
Total	100.0%	100.0%	100.0%

proportions where a combination of the two is to be tested. Add kerosene to the extent of 5% of the weight of sand and 10 per cent of the weight of filler and mix thoroughly. Then transfer the entire contents of the saucer to a cylindrical iron mold having an accurately determined diameter of approximately 5.08 cm. (2 in.). The forming mold employed in the stability test may be used for this purpose and should rest on a flat metal plate. Insert a close fitting plunger in the mold and subject the mixture to a load of 3,000 lbs. per sq. in. for one minute. Release the load and measure the height of the compressed mixture in the mold to .01 cm. This may be done by subtracting the height of the plunger in the empty mold from its height when resting on the compressed mixture. Without reference to the kerosene present calculate voids in the mineral aggregate from the following formu-

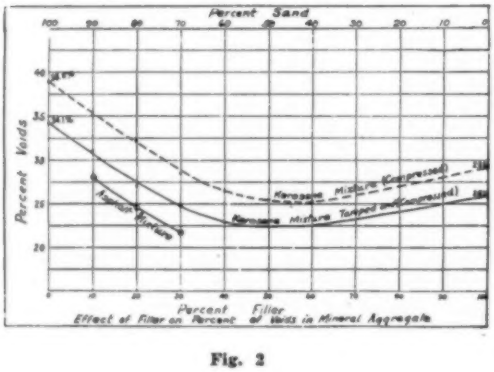


Fig. 2

las in which V=volume of compressed mixture in cc.; d=density of the compressed mineral aggregate; D=theoretical maximum density of the total mineral aggregate considered as a voidless solid; G and G'=the specific gravities of the sand and mineral filler respectively, which must be predetermined by any of the well known methods; and W and W'=the percentage weights of sand and mineral filler respectively which were present in the dry aggregate.

$$(1)\quad d = \frac{100}{V}$$

$$(2)\quad D = \frac{100}{\frac{W}{G} - \frac{W'}{G'}}$$

$$(3)\quad \%\ \text{Voids} = \frac{100\ (D-d)}{D}$$

Results obtained by this method on various combinations of the sand and limestone dust previously described are shown by the upper curve in Fig. 2 which is seen to be quite regu-

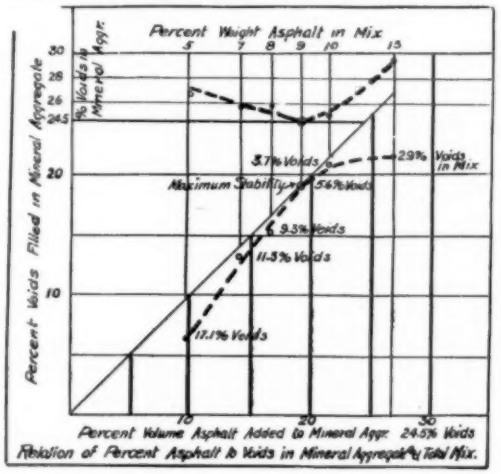

Percent Weight Asphalt in Mix
% Voids in Mineral Aggr.
Percent Voids Filled in Mineral Aggregate
3.7% Voids
29% Voids in Mix
Maximum Stability
5.6% Voids
9.3% Voids
11.3% Voids
17.1% Voids
Percent Volume Asphalt Added to Mineral Aggr. 24.5% Voids
Relation of Percent Asphalt to Voids in Mineral Aggregate & Total Mix.

Fig. 3

lar and shows a minimum percentage of voids in the aggregate containing 50 per cent each of sand and dust.

After it had been decided to tamp the asphalt mixtures for stability tests the same method of tamping was adopted for the kerosene mixtures used in void determinations with results shown by the second full curve which is seen to be almost parallel to the first curve but showing from 3 to 5 per cent lower voids for individual combinations. Relatively these two curves are the same, with corresponding high and low points so that either might be used as a general guide in selecting

a practical combination of sand and dust which would approach the minimum percentage of voids as closely as possible.

It should be realized however that in any mineral aggregate, no matter how thoroughly compressed, the individual particles are not in absolute contact even at points but are separated by films. In the case of dry aggregates air films and in liquid mixtures liquid films exist between the particles. While the authors felt that the kerosene method of determining voids represented approximately the same degree of close packing without segregation as any dry method, they felt that none of the methods might correctly show the degree of close packing of the mineral particles in any asphalt paving mixture as the films of asphalt might be greater or less than the films of air or kerosene. To obtain some information on this matter they therefore adopted the following method of calculating voids in the mineral aggregate in asphalt mixtures, irrespective of whether these voids were completely or only partly filled with asphalt.

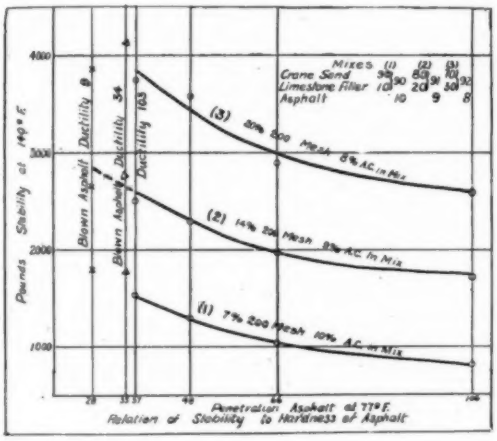
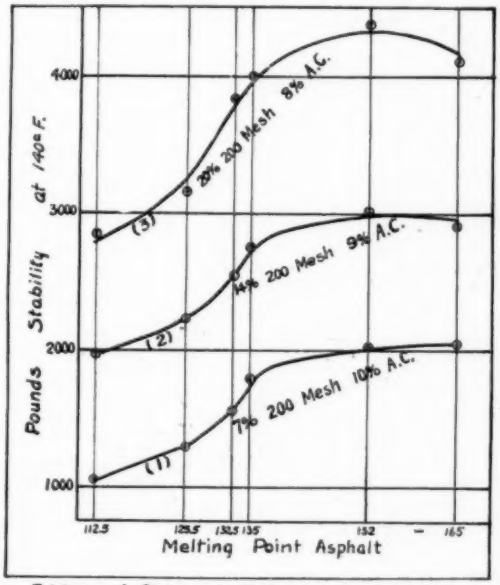


Fig. 4.

The specific gravity of the compressed asphalt briquette was first determined. From this determined weight of a unit volume the weight of asphalt present was subtracted to obtain the weight or specific gravity of the same volume of mineral aggregate and the percentage voids in the mineral aggregate was then calculated by means of formulas (2) and (3). Results so obtained for the three asphalt mixtures that had been selected for further investigation are shown by the short curve in Fig. 2 where it is seen that the presence of asphalt in the amounts used further reduced the voids in the mineral aggregate. In other words the mineral aggregate was more closely packed and the asphalt films separating the individual grains were thinner than either the films of air or kerosene. This is probably due to the relatively high viscosity and cementitiousness of the asphalt but is an important factor to be considered if the percentage of voids in the mineral aggregate is to set the maximum allowable amount of asphalt to be used in a paving mixture, which assumption has been made by a number of paving technologists.

Relation of Stability to Voids.—Following this work some interesting studies of the relation of stability to voids were made in connection with the tests illustrated in Fig. 1. For each compressed mixture the voids in the mixture itself were determined and the voids in the mineral aggregate, excluding the asphalt, were calculated to ascertain its closeness of packing. In each series it was found that maximum stability was developed where the mineral aggregate was most closely packed but that such mixtures did not show the lowest percentage of voids in the series. These relations are illustrated in Fig. 3 for the 20 per cent filler series and are typical of those developed by the other two series.

If 24.5 per cent voids in the asphalt coated mineral aggregate, the lowest percentage obtained, is considered to represent maximum practical density it is seen from the upper curve that as the percentage of asphalt is



Relation of Stability to Melting Point of Asphalt

Fig. 5.

increased from 5 per cent by weight, closeness of packing is gradually increased to a maximum at 9 per cent after which it rapidly decreases with further addition of asphalt. Reference to the lower curve for which the asphalt has been calculated on a volume basis shows that further addition of asphalt de-

creases the percentage of voids in the total mixture but not in proportion to the volume increase in asphalt. It is believed that too little asphalt tends to prevent the closest possible packing of the mineral aggregate because of lack of mobility of the mixture during compression and that too much asphalt tends toward the same result by creating a pasty mixture which is apt to trap air. Thus when more than 24.5 per cent by volume of

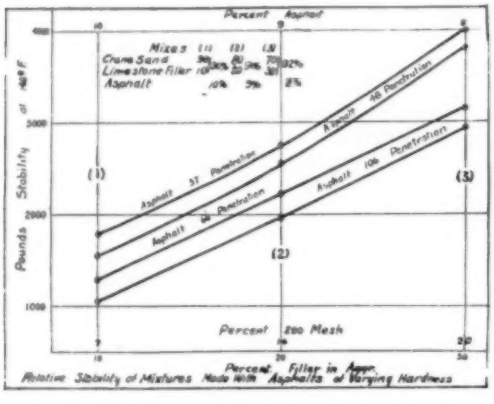


Fig. 6.

the asphalt was used, or an amount which should have reduced the voids in the mixture to zero, nearly 3 per cent of voids was actually found.

Relation of Stability to Hardness.—The establishment of an apparently logical reason for the relatively high stabilities of mixtures Nos. 1, 2 and 3 justifies their selection for further comparative study. Figure 4 illustrates the effect upon their stability of variations in penetrations of asphalt cement.

Here it is seen that there is a very similar and definite increase in stability with decrease in penetration (increase in hardness) of the steam refined or fluxed asphalts of high ductility. Projections of these curves into the penetration range covered by the blown or oxidized asphalts of low ductility as in the case of mixture 2 indicates that the stability values obtained for the latter are only what might reasonably be expected from their lower penetration or greater hardness. In other words no direct relation between stability and ductility can be established.

Relation of Stability to Melting Point of Asphalt.—Figure 5 shows that a fairly consistent relation between stability and melting point of the asphalt may be established but that it is not as regular or definite as the relation between stability and penetration. In general it is seen that stability increases most rapidly with increase in melting point up to the approximate temperature at which the test is made, after which further increase in melting point produces relatively less increase in stability. It should of course be realized that the so called melting point is a misnomer as asphalts have no true melting point. The test is therefore only an approximation of a temperature at which the asphalt reaches a certain rather indefinite degree of fluidity.

For any given penetration of asphalt the direct relation between stability and percentage of filler is more clearly shown in Fig. 6 than in the preceding figures. Here it is at once apparent that stability is more influenced by the percentage of filler than by even wide variation in characteristics of the asphalt cement. For instance the stability of mixture 3 with the very soft asphalt of 106 penetration is higher than that for mixture 2 with a hard asphalt of 37 penetration. The possible significance of such relations will appear later.

That mere increase in filler will not necessarily increase stability unless the percentage of asphalt is adjusted accordingly is very clearly shown in Fig. 7 where the stability values given in Fig. 1 for the 8, 10 and 13 per cent asphalt mixtures are plotted against

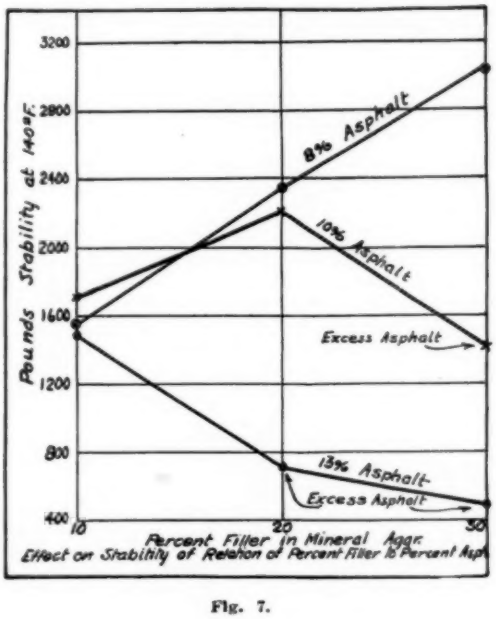


Fig. 7.

the percentage of filler in the mineral aggregate. In this figure it will be noted that the stability values of the 10 per cent filler mixtures are quite close together irrespective of the variation in asphalt between 8 and 13 per cent. In the 8 per cent asphalt series stability increases consistently with increase in filler up to 30 per cent. In the 10 per cent asphalt series stability increases with increase

in filler to 20 per cent and then falls off at 30 per cent filler, while in the 13 per cent asphalt series stability is consistently reduced with addition of filler, which is exactly the reverse of the 8 per cent asphalt series. The probable reason for such variation in trend of results is now quite readily explainable from the previous discussion of voids or closeness of packing of the mineral aggregate.

Effect of Variations of Temperatures.—Up to this point all of the stability tests which have been considered were made at a temperature of 140° F. It has been quite generally assumed that this temperature is about the maximum which the asphalt pavement reaches under ordinary conditions but records of pavement temperature as high or higher han 140° F. have been obtained by the Federal Bureau of Public Roads as far north as Washington, D. C., and it is quite probable that higher maximums occur for short periods in many parts of the United States. It was therefore considered advisable to obtain some idea of the effect of variation in temperature upon the stability of various mixtures. Accordingly a series of tests upon mixtures 1, 2 and 3 with the different asphalts was run at temperatures of 100°, 140°, 150° and 160° F. The relative effect of variation in temperature

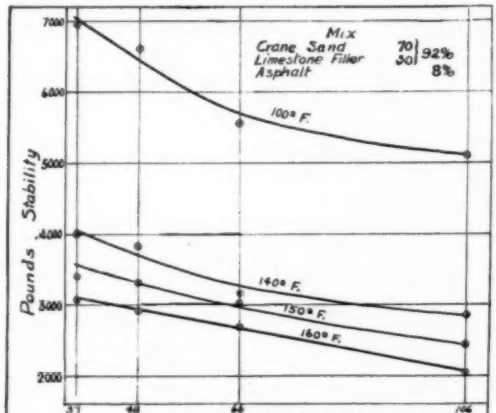


Fig. 8.

upon all three mixtures was found to be very similar and is illustrated by Fig. 8 covering mixture 3.

Here each curve represents a series of tests at a single temperature and shows the stability at such temperature as affected by the penetration of the asphalt cement used in the mixture. It will be noted that the same general type of curve occurs at all four temperatures and that stability is invariably increased with decrease in penetration of the asphalt although as the temperatures becomes less there is a tendency for the curves to become steeper. This of course means that, at comparatively low temperatures, when the mineral aggregate remains the same, hardeninb the asphalt tends to increase stability more markedly than at high temperatures. With regard to the effect of mineral filler it may be stated that curves at the same temperature for all three mixtures showed in-

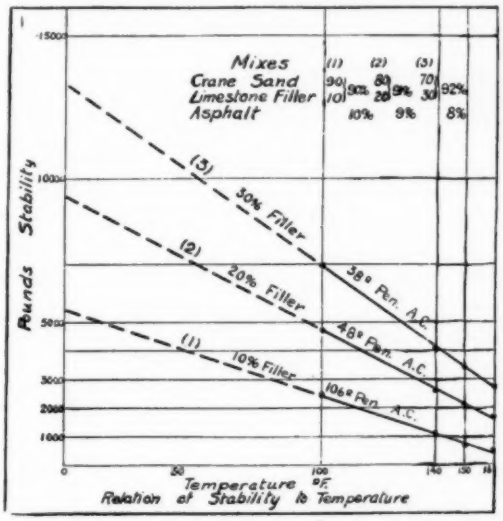


Fig. 9.

creasing stability values as the percentage of filler became greater.

Relation of Stability to Temperature.—The direct effect of temperature upon the stability of individual mixtures is of very great interest from a practical standpoint and each mixture with its various asphalts was so plotted. Figure 9 shows the relations developed by the extremes and average of the steam refined asphalt mixtures, and may be considered as typical.

It is seen in each case that, within the temperature range at which tests were run, practically straight line relations exist and that for a given mix with a given degree of compression stability is apparently a direct function of temperature of the mix, and increases as the temperature decreases. Some variations from this rule were found in the case of certain mixtures, possibly due to experimental errors, but so many of the mixtures developed this approximately straight line relation that the existence of a law is fairly well indicated. If further investigations confirm this relation it will make it possible t o determine the stability of a given mixture at any temperature by making two determinations at different temperatures and projecting

a straight line in both directions through the values obtained.

The dotted lines in Fig. 9 are projections of the stability values of the three mixtures to 0° F. at which temperature very wide differences are shown. It is quite well understood in the paving industry that some mixtures which have proven very stable, become so hard and brittle as to crack badly at low temperatures. It is very necessary therefore that in any attempt to increase stability this factor should be kept in mind. If the straight line temperature relation is confirmed a practical means of controlling tendency to crack is at once indicated as a use of the stability test and the authors hope shortly to concentrate on this phase of their investigation. The field is promising as it has already been pointed out that the same degree of stability at a relatively high temperature may be obtained with a soft asphalt and a high percentage of filler as with a hard asphalt and a lower percentage of filler.

The temperature slopes of such mixtures are however different so that considerable differences in stability at low temperatures are indicated and it would seem that between two mixtures with the same stability at 140° F. the one showing a slope with the lesser pitch would be the more resistant to cracking.

Deductions from Investigation.—In recapitulation particular attention is directed to the following deductions which may be drawn from this investigation of factors affecting the stability of asphalt paving mixtures.

1. Closeness of packing or reduction of voids by compression of the mineral aggregate exerts a much greater stabilizing effect that the mere reduction of voids in the entire mixture. Specific gravity or density of the mixture itself is therefore not always a direct indication of either degree of compression or stability.

2. Asphalt films surrounding the particles of compressed mineral aggregates may be thinner than the air or liquid films which exist in the usual methods of determining voids. Therefore any attempt to proportion asphalt in a mixture with the idea of completely filling the voids as determined in the mineral aggregate may result in the use of too much asphalt with a marked reduction in stability.

3. The greatest stability for a given mineral aggregate has not been obtained with that proportion of asphalt which would produce the lowest percentage of voids in the compressed mixture. The fact that further reduction of voids in the mineral aggregate is likely to occur under traffic after a pavement has been laid, due both to additional compression and internal wear, indicates that from the standpoint of stability mixtures should be designed so as not to be completely voidless even after thorough compression during construction. Cases have been noted where pavements have been quite stable for a number of years following construction and have afterwards suddenly become unstable with no sudden change in traffic. It is believed that in such cases while the proportion of asphalt was originally satisfactory for the degree of compaction of the mineral aggregate, a further reduction in its voids under traffic made the quantity of asphalt excessive.

4. In order to secure maximum stability in paving practice the percentage of asphalt must be controlled within much narrower limits for high filler low void aggregates than for relatively low filler high void aggregates.

5. Of the physical characteristics of asphalt, which are usually determined, penetration at 77° F. appears to exert the most direct and definite effect upon stability of the mixture at all temperatures and a general increase in stability, produced with a given mineral aggregate, accompanies decreases in penetration of the asphalt.

6. Next to closeness of packing of the mineral aggregate, percentage of filler appears to be the greatest stabilizing factor in paving mixtures and provided the proper proportion of asphalt is used increased stability is invariably produced by increase in filler at least to the extent that such addition decreases voids in the mineral aggregate. If however the proper proportion of asphalt is not used an increase in filler may result in decrease in stability.

7. The stability of a given compressed mixture appears to be directly proportional to its temperature but the proportion varies for different mixtures so that of two mixtures which show the same stability at 140° F. one may be much harder and more likely to crack at low temperatures than the other.

Local Conditions Influence Design

An engineer was engaged to locate a proper outlet for a drainage ditch, states the Highway Magazine. He came to a road under which was built a new concrete culvert. To his amazement he beheld a culvert of new and strange design. His ready rule came forth, and he found the inlet end to measure 4 ft. in diameter and the outlet end but 2 ft. When he drove to town that afternoon he "hunted up" the county surveyor and asked him the reason for the unusual culvert. The surveyor was an old fellow and replied, rather patronizingly: "My boy, that culvert is an engineering work designed to meet local conditions and not plain theory. You see that road is on the township line, and the supervisors on the west side insisted on 4 ft. as about the right size for their end, while the supervisors on the east claimed 2 ft. was enough."

Connecticut Transportation Survey

Digest from Public Roads of Report of a Survey of Transportation in the State Highway System of Connecticut

The general purpose of the survey was to obtain the traffic information necessary for the establishment of a definite plan of highway improvement based on the present and expected future traffic.

A classification of all highways on the basis of their relative traffic importance was felt to be the first need. Such a classification is required to determine the order in which the highways should be improved and the distribution of construction and maintenance funds over the highway system.

The selection of the most economical type for each highway is the next step. Such a selection must be based not only upon the present and expected future traffic density but also upon the type of the traffic units. The more important considerations are: (1) The present and estimated future density of traffic; (2) the ratio of the number of trucks to the number of all vehicles; (3) the relative number of trucks of large, medium, and small capacities; and (4) the maximum wheel loads and the frequency of heavy gross loads and wheel loads.

The final selection of the type of surface depends also upon physical considerations such as topography, drainage, soil and subgrade conditions, availability and cost of materials, as well as upon traffic considerations.

In addition to these purposes it was also planned to determine the place of highway transportation in the transportation system as a whole, and to establish the principles which should form the basis for the coordination of highway transportation with other forms in order to develop as a whole the most efficient transportation system.

The survey was begun in September, 1922, and continued for one year, during which time traffic data were recorded at the 57 survey stations. These stations, carefully located and designated before the beginning of the survey, were operated on an average of once a month by "recording" parties which recorded all passenger-car information and the principal types of motor-truck information, with the exception of the weights of the vehicles. Nine hours constituted the length of each operation at a station; the actual hours, however, varied with each operation and ranged between 6 a. m. and 9 p. m. A sufficient number of night operations were made to enable the correction of all traffic counts to an average 24-hour day.

In addition to the operation by recording parties, 8 of the 57 stations were operated by a "weight" party, which recorded all motor-truck traffic information, including weights of vehicles. These eight stations were located at key points on the principal highways in different sections in order that practices in motor-truck loading in various parts of the State could be determined.

Variations in Traffic.—It is evident that the routes connecting important centers of population and industry carry the heaviest traffic. The Boston Post Road from Greenwich to New Haven is the most important highway in the State and the same route from New Haven north to the Massachusetts line is almost of equal importance. In general, the traffic tends to vary directly with the population and industry served by the route and inversely as the distance from centers of population and industry.

With the exception of the route from Greenwich to Westerly, the general direction of the important traffic routes is north and south. Other east and west routes although of considerable importance are secondary to the north and south routes.

Traffic varies greatly with the seasons of the year and the days of the week. Considering all types of vehicles, Sunday is the day and August the month of maximum total traffic.

Variation in truck traffic is considerably less than the variation in passenger-car traffic. The monthly variation in passenger-car traffic ranges from 29 to 193 per cent of the average. For truck traffic the corresponding range is from 68 to 122 per cent. Truck traffic is very uniform from Monday through Friday. On Saturday it is somewhat lower than on other week days, and on Sunday it is very low compared with other days of the week. Maximum daily truck traffic is approximately 146 per cent of the average daily truck traffic for the year.

In connection with the survey a map showing the distribution of population was prepared for comparison with the map showing the distribution of traffic. It is evident from this map that there is a relation between them. Of the 17 towns (the town in Connecticut cor-

[1] The complete report of the survey undertaken jointly by the Bureau of Public Roads and the Connecticut State Highway Department has recently been issued. Copies may be obtained from the Bureau of Public Roads, Washington, D. C., upon request as long as the supply lasts.

responding roughly to the township in other States) having a population in 1920 of 640 or more per square mile, 16 are traversed by the seven routes which have been classified as the principal routes.

The areas adjacent to the principal routes are increasing in population at a more rapid rate than other sections of the State, the rate of increase varying from 17.2 to 39 per cent, whereas the rate of increase for the remainder of the State is only 4.7 per cent. The more rapid rate of population increase in the areas adjacent to the principal highways indicates the urgent need for the planning and construction of highways to serve future traffic needs in these areas.

The present distribution of population and the trends of population growth as reflected in the more rapid increase in the densely populated areas and the more rapid increase in urban than in rural population indicate that the present main traffic routes will continue to be the important routes and may increase in relative importance. The changes in relative importance of main traffic routes, as compared with those of secondary importance, must of necessity be slow and will not be important during the next few years.

The present trends indicate that minor traffic routes will with some exceptions continue to be of minor importance. The present areas of low population density and of decreasing or slowly increasing population will not become important traffic areas during the next decade.

Motor Truck Capacities and Loading.—The design of highways and the types of pavements to be selected are dependent not only upon the amount of traffic using them but also upon the type and weight of the traffic. The number of vehicles indicates the general importance of one route as compared with another and is the most important factor in considering highway width, parallel routes, and elimination of grade crossings and "bottle necks." But the determination of the amount of traffic does not form sufficient or conclusive evidence for the final selection of highway design and type of pavement.

Analysis of traffic on the Connecticut roads reveals entirely different types of traffic on various highways. The first difference noted is a higher proportion of motor-truck traffic on one highway than another. This can be illustrated in the case of two highways, one of which connects two large industrial centers and the other a city and a pleasure resort. The latter highway would naturally be mainly a passenger-car route and be used less by motor-truck traffic (in proportion to total traffic) than the route connecting industrial centers. A more searching analysis reveals variation in motor-truck traffic itself; a preponderance of large-capacity trucks and heavy gross loads on one route and of small-capacity trucks and light gross loads on another.

Variation in the capacity, loading, and tire equipment of the vehicles causes corresponding variations in the effect upon the highways. Light, pneumatic-tired vehicles have less effect than heavy, solid-tired vehicles.

Variations in the rated capacities of motor trucks using highway routes are an excellent basis for determining the type of motor-truck traffic. Small-capacity trucks are designed to carry light loads and although overloading (loading beyond the rated capacity of the truck) is not uncommon, it can not be practiced beyond a certain degree. The rated capacity of a truck is found to bear a close relation to the average load transported by it; and the capacities of all trucks using a highway will bear a similar relation to the tonnage transported over the highway. The proportion of light, medium, and heavy trucks passing over the highways of a State is the primary factor in the determination of types of motor-truck traffic.

Additional evidence concerning motor-truck traffic is obtained by an anlysis of net and gross loads and of rear-axle and wheel loads. This evidence is not only valuable in the selection of highway design and type of pavement but also in traffic control and the regulation of overloading.

Sizes of Trucks.—One-half ton is the predominant capacity of motor trucks using the Connecticut highways, approximately one-fourth of all trucks recorded during the survey being of that size. Most important, however, from the standpoint of the weight and number of the vehicles, is the 5-ton capacity, which was represented in the traffic by one-tenth of the total number of trucks. Table I shows relatively the number of motor trucks of all capacities observed in the State as a whole during the survey period. The trucks of 1-ton capacity and under represent on the highways a much smaller percentage of the total traffic than they do of the total registration, while all other capacity groups are present in greater proportion in the traffic than in the registration lists. It is apparent, however,

Table I.—Distribution of observed motor trucks by capacity[1]

Capacity of trucks	Percentage of total number of observed trucks	Capacity of trucks	Percentage of total number of observed trucks	Capacity of trucks	Percentage of total number of observed trucks
Tons	Per cent	Tons	Per cent	Tons	Per cent
½	25.1	2	9.7	5	10.2
¾	3.8	2½	3.7	5½	.4
1	18.4	3	1.7	6	.3
1¼	12.5	3½	6.7	6½	.6
1½	6.0	4	.7	7½	.2

[1] Based on 82,738 trucks.

from Table I that, in the State as a whole, the motor-truck movement consists very largely of small-capacity trucks, although the heavy-truck movement is much heavier than the registration of such trucks would indicate.

It is possible from a study of the capacity of trucks using the highways of the State to classify certain routes, for the purposes of highway design and surface type selection, as terminal highways and others as class A, B, and C highways. A terminal highway may be defined as a highway connecting large industrial centers, not widely separated between which there is a daily motor-truck traffic which consists of a large number of trucks of all capacities but especially of large-capacity trucks. Class A highways may be defined as carrying a smaller number of motor trucks of all capacities than terminal highways; class B highways as those the traffic of which consists mainly of small-capacity trucks; and class C highways as those over which the traffic of motor trucks of all capacities is relatively unimportant. In addition to the classification of highways, it is possible from a study of the movement of trucks of various capacities to establish certain general principles regarding the movement.

Several significant features are observable in the movement of small and large-capacity trucks over the Connecticut highway system. One of these is the great Connecticut highway system. Several sig- volume of ½ to 2½-ton trucks observed around large centers of population and between adjacent large centers of population. This condition is apparent around Hartford, New Haven, and Bridgeport and is accounted for, in large part, by the fact that large cities and towns are distribution centers for commodities and because, in this distribution of commodities, the small-capacity truck is in general the most economical unit. The movement of small-capacity trucks is predominantly a local or short-haul movement. This is particularly true of the ½ to 1½-ton trucks, the average trip mileage of which ranges from 12 to 18 miles. Table II shows the average trip mileage of motor trucks of various capacities.

The location of the State is a contributory factor to the long-haul movement of large-capacity trucks. Connecticut is a highly developed industrial area and its highways are the main traffic arteries between New York City and New England points, resulting in a large proportion of long-distance haulage by large-capacity vehicles.

Truck Overloading Practices. — Approximately two-thirds of all motor trucks observed on the Connecticut highways during the course of the survey were loaded.

Comparing the large and small-capacity trucks, it was found that a somewhat larger proportion of the former were loaded. Of the total number of ½-ton trucks, for instance, 60.5 per cent were found to be loaded; while the loaded 5-ton trucks were 66.3 per cent of the total number. Although the differences between the proportion of loaded small-capacity and large-capacity trucks are not very great, it is apparent that the large-capacity trucks more frequently get return loads.

The general tendencies in motor-truck loading are shown by the average net and gross weights for trucks of each capacity as recorded in Table III.

There is a tendency to load the 2, 2½, 3½, 5, and 6-ton trucks nearer the limit of their rated capacities. Trucks of these capacities can therefore be expected to be the principal motor trucks carrying loads in excess of rated capacity, since the ratio of their average net load to their capacity is higher than in the case of the other capacities.

Almost one-third of the loaded motor trucks observed on the Connecticut highways during the survey carried net loads in excess of their rated capacities. Of the total number of loaded trucks, 30.2 per cent were loaded over their rated capacity and 2.1 per cent had gross weights in excess of 25,000 lbs. Of all sizes of trucks, those of 2, 2½, 3½, and 5-ton capacity were found most frequently to be loaded beyond their rated capacity. The percentages of trucks of these sizes so overloaded were 38.1, 41.8, 38.1, and 41.1 per cent, respectively.

The fact that 2.1 per cent of the total gross loads exceed the 25,000-lb. legal limit is significant. No gross loads over 25,000 lbs. were

Table II.—Average trip mileage of motor trucks of various capacities

Capacity	Average trip Miles	Capacity	Average trip Miles
½ ton	12	4 tons	30
¾ ton	17	5 tons	45
1 ton	15	5½ tons	54
1¼ tons	18	6 tons	36
1½ tons	17	6½ tons	42
2 tons	27	7½ tons	60
2½ tons	34		—
3 tons	29	All capacities	22
3½ tons	33		

Table III.—Average net and gross weight of trucks of the several capacities

Capacity	Number of trucks	Average net weight pounds	Average gross weight pounds
½ ton	5,072	720	2,950
¾ ton	1,375	1,090	5,210
1 ton	5,167	1,440	4,370
1¼ tons	3,443	1,560	5,270
1½ tons	1,679	2,310	7,350
2 tons	4,435	3,570	10,040
2½ tons	1,859	4,660	11,580
3 tons	335	4,430	12,770
3½ tons	3,507	6,020	15,820
4 tons	148	6,690	16,820
5 tons	6,897	8,680	20,170
5½ tons	236	8,440	20,380
6 tons	16	10,900	22,200
6½ tons	430	10,180	22,590
7½ tons	218	9,520	22,200

found on trucks of 3-ton capacity or smaller. It would be almost impossible for trucks of these smaller sizes to carry a 25,000-lb. gross load. For this reason it would probably be more accurate to compute the percentage of loads in excess of the gross-weight limit on the basis of the number of loaded 3½ to 7½-ton trucks. Applying this method it is found that of the total number of 3½ to 7½-ton loaded trucks recorded, 6.4 per cent were loaded in excess of 25,000 lbs. gross. On the terminal and class A highways overloaded trucks are more frequent. The highest percentage of trucks loaded beyond their rated capacity was found on the Boston Post Road.

Type of Tire Equipment.—Pneumatic tires are used on 99 per cent of the ½-ton trucks. They also form the chief tire equipment for the ¾, 1, 1¼, and 1½-ton trucks. The trucks of larger capacity are mainly equipped with solid tires on both front and rear wheels, although there is some usage of combinations of the two tire types, using the solid type on the rear wheels and the pneumatic type on the front wheels.

The average net and gross loads of trucks very considerably for trucks of the same capacity according to the type of tire equipment. Trucks equipped with pneumatic tires on both front and rear wheels are, in general, less heavily loaded than those which are equipped either with solid tires only or with a combination of pneumatic and solid tires. The heaviest loading occurs on the trucks that have solid tires on all four wheels.

Analyzing the trip mileage of the trucks with respect to the tire equipment, it appears that the majority of pneumatic-tired trucks—84.5 per cent—travel less than 40 miles. Of the solid-tired trucks, 58.8 per cent travel less than 40 miles; and of all trucks with the three types of tire equipment, 3.5 per cent of the pneumatic tired, 12.9 per cent of the solid tired, and 24 per cent of those equipped with a combination of solid and pneumatic tires, travel 100 miles or more at a trip.

Loads Per Inch Width of Tire.—In order to determine the extent of violation of the statute prohibiting loads in excess of 800 lbs. per inch width of solid tire and also providing that no commercial vehicle shall be so loaded that the weight on one axle is less than 20 per cent of the gross weight, an analysis was made of the weights of 4,580 loaded trucks. Excess loads per inch of width for the front axle were found to be exceptional. Of the 4,580 trucks analyzed, 102, or 2.2 per cent, were found to have loads in excess of 800 lbs. per inch width of tire on the rear axle.

Examining the extent to which the overloading indicated by violation of this statute is confirmed by the other determinants of overloading—that is, loading in excess of rated capacity and loading in excess of 25,000 lbs. gross weight—it is found that of the 4,580 trucks referred to above, 2,810, or 61.4 per cent, were loaded to less than their rated capacity and of these only 20, or 0.7 per cent, were loaded in excess of 800 lbs. per inch width of tire, channel measurement. Of the 1,770 trucks, 38.6 per cent of the total number, that were loaded in excess of rated capacity, 82, or 4.6 per cent, were loaded in excess of 800 lbs. per inch width of tire, channel measurement; and of the 144 trucks the gross weight of which exceeded 25,000 lbs., 27, or 18.8 per cent, violated the tire-weight statute.

Data are also recorded and analyzed in the report as to the results secured by determining the width of tires by inside channel measurements and actual road contact measurements. The results indicate that a limitation of 800 lbs. per inch of tire, channel measurement, is approximately equivalent to a limitation of 1,000 lbs. per inch of width measured at the point of contact with the road surface.

Measurements were also taken of the thickness of solid truck tires. Very few trucks were encountered with tires less than 1 in. in thickness and the number operating on tires less than 1.5 in. in thickness varied from 2.8 per cent of the loads in excess of 25,000 lbs. gross weight to 8.5 per cent of the trucks with less-than-rated-capacity loads. Over 60 per cent of all trucks operate on tires between 1.5 and 2.4 in. in thickness.

Highway Utilization.—Net tonnage transported is the most reliable basis for the measurement of the service value of a highway for the transportation of commodities.

The 1,114 miles of improved highways in the State trunk-line system carry an average of 159,000 net ton-miles and 575,000 gross ton-miles of motor-truck traffic per day. During the year period—September, 1922, to September, 1923—these highways carried approximately 58,000,000 net ton-miles and approximately 210,000,000 gross ton-miles of truck traffic. During the same period the total vehicle utilization of the State system was approximately 414,000,000 vehicle-miles, of which 59,700,000 were truck-miles and 354,300,000

Table IV.—Trip Mileage of Passenger Cars Used for Business and Nonbusiness Purposes

Trip mileage	All passenger cars Per cent	Business cars Per cent	Non business cars Per cent
0-19	55.7	65.3	48.0
20-39	16.3	14.4	17.9
40-59	9.2	8.2	10.1
60-79	5.0	3.9	5.9
80-99	3.6	1.7	5.1
100-149	4.3	3.3	5.1
150-199	1.7	1.2	2.1
200-299	2.7	1.5	3.7
300-399	.5	.2	.7
400-499	.2	.1	.4
500 and over	.8	.2	1.0
Total	100.0	100.0	100.0

were passenger car-miles. The State trunk highway system includes 7.2 per cent of the total highway mileage in the State. The State-aid system includes 4.3 per cent and the town roads 88.5 per cent of the total mileage in the State. No accurate data regarding the vehicle-mileage utilization of the State-aid and town highway systems are available; but on the basis of scattered data it is estimated that approximately 60 per cent of the total vehicle mileage is on the State highway system, and that the total annual vehicle-mileage utilization of all highways in Connecticut is therefore approximately 690,000,000 vehicle-miles.

Of the annual 354,300,000 passenger car-miles on the State system, 32.3 per cent, or approximately 114,400,000 passenger car-miles, represents the business use of passenger cars, and 67.7 per cent, or approximately 239,900,000 passenger car-miles, represents the nonbusiness use of passenger cars. The average trip mileage of passenger cars used for business purposes is considerably below the corresponding average for nonbusiness usage, as indicated by the analysis of the two kinds of usage presented in Table IV.

Of all passenger cars using the highways, 44.5 per cent are business cars and 55.5 per cent nonbusiness cars. The variation between the proportion of business and nonbusiness usage on a vehicle basis and on a mileage basis is due to the shorter average trip mileage of business cars.

The percentage of all cars used for business and nonbusiness purposes, classified according to trip mileage, are shown in Table V.

The number of passengers per car averages 2.7 persons for all passenger cars. For business cars the average is 1.8 persons, and for nonbusiness cars, 3.2 persons. The passenger mileage on the State highway system for the year period was 206,000,000 for business cars and 768,000,000 for nonbusiness cars, or a total of 974,000,000 passenger-miles.

State System Earns Big Return on Investment.—Applying assumed values for saving in vehicle operation of 1 cent per passenger car-mile and 3 cents per truck-mile to the traffic on the 1,114 miles of the State trunk highway system, an estimated service value of the highway system can be obtained. As stated before, the annual vehicle mileage on this system during the year period—September, 1922, to September, 1923—was approximately 414,000,000 vehicle-miles, of which 59,700,000 were truck-miles and 354,300,000 were passenger car-miles. On this basis of valuation the annual service value of the system is $1,791,000 for truck traffic and $3,543,000 for passenger car traffic, a total of $5,334,000 for the system.

A valuation based on motor-vehicle operating costs, however, does not represent the total service value produced by the highway system and the vehicles using the highways. Highway improvements increase real property values. Highway transportation adds time utility to the value of goods by the rapid movement at the time of demand and also produces place utility by making goods available for use by transporting them from the place of supply to the place of demand.

The value in 1923 of the 1,114 miles of improved highways on the State trunk-line system, including bridges but exclusive of right of way, is estimated by the Connecticut State Highway Commission at approximately $23,000,000. Based on the above estimate of the service value of the highway system to highway users, and without considering the additional service value indicated above, the State trunk highway system earns an annual return of approximately 23 per cent on the investment.

Vehicles of foreign registration form an important part of both motor-truck and passenger-car traffic on the State system. Foreign trucks comprised 10.9 per cent of all trucks recorded, but on account of their greater trip mileage (40 miles over Connecticut roads as compared with 14 miles for Connecticut trucks) the utilization on a ton-mileage basis is much higher. They also carry a greater tonnage than the Connecticut trucks. This is to be expected, since most of them are operating on the longer hauls where the larger capacities are generally used. On the basis of ton-mileage the foreign trucks furnish almost one-third of the total truck traffic.

Passenger cars of foreign registration were 21.1 per cent of all passenger cars recorded and furnished 43.4 per cent of the total passenger-car mileage.

Transportation of Commodities.—In 1923 there were 29,140 and in 1924 33,776 motor trucks registered in Connecticut. These motor trucks were in constant use carrying commodities over the highways and streets. During the period—September, 1922, to September, 1923—the haulage of these commodities over the 1,114 miles of the state highway

Table V.—Percentages of All Passenger Cars Used for Business and Nonbusiness Purposes, Classified According to Trip Mileage

Trip mileage	Business cars Per cent	Nonbusiness cars Per cent
0-19	52.2	47.8
20-39	39.3	60.7
40-59	39.4	60.6
60-79	34.8	65.2
80-99	21.6	78.4
100-149	34.5	65.5
150-199	30.9	69.1
200-299	24.6	75.4
300-399	17.6	82.4
400-499	17.2	82.8
500 and over	12.6	87.4
Total	44.5	55.5

system amounted to approximately 58,000,000 ton-miles and the inclusion of other highways and city streets would substantially increase this amount.

Motor-truck transportation in the state is of three principal types.

1. Transportation within the market and trading area of a city or town, including—

(a) Distribution of commodities from wholesaler to retailer, and from retailer to consumer.

(b) Marketing of commodities produced in the area, and

(c) Pick-up and delivery service between railroad or water terminals and shipper and consignee.

The movement is purely local, the major part of it being within the city or town. It uses the rural highways only in so far as the market or trade area of the city extends beyond its political limits.

2. Complete transportation from the shipper's place of business to the consignee's place of business for comparatively short-haul shipments. This type of transportation is interurban rather than local or suburban in character and is generally limited to distances of less than 40 miles.

3. Comparatively long-distance transportation, including—

(a) The transportation of specialized commodities, notably those which require a special preparation for shipment by rail or water that can be avoided by motor-truck shipment; and those which, because of their high value or their perishability, require rapid-delivery service; and

(b) Emergency transportation during periods of congestion and embargoes on other transportation facilities.

From Table VI it is evident that of the total net tonnage transported over the state highway system more than one-third is moved distances of less than 10 miles, approximately two-thirds is moved distances of less than 30 miles, and only 15.2 per cent is moved distances of 60 miles and over. The table includes commodities transported over the state system only and excludes the large volume of motor-truck tonnage which is transported over city streets.

Approximately 350 distinct commodities were recorded on trucks using the state highway system during the period of observation, but of the total net tonnage 69 per cent was made up of manufactured goods. The distribution by types of commodities is shown in Table VII.

Table VI.—Distribution of net tonnage of commodities transported by motor truck over the Connecticut State highway system by length of haul

Length of haul (miles)	Proportion of total net tonnage Per cent	Length of haul (miles)	Proportion of total net tonnage Per cent
0-9	36.3	70-79	2.6
10-19	19.2	80-89	.8
20-29	11.6	90-99	1.0
30-39	9.1	100 and over	8.6
40-49	4.0		
50-59	4.6	Total	100.0
60-69	2.2		

Table VII.—Principal commodities transported by motor truck on State highway system

Commodity	Percentage of total net tonnage	Commodity	Percentage of total net tonnage
Groceries	6.8	Ice cream	2.0
Gravel, sand, and crushed rock	5.3	Iron and steel bar	1.8
General express	4.8	Brick	1.5
Gasoline	4.5	Feed and grain	1.5
Household goods (used)	4.5	Furniture (new)	1.4
Coal	3.3	Vegetables	1.3
Lumber	3.3	Paper	1.2
Bread and bakery goods	3.0	Wire	1.1
Meat, fresh	2.9	Ice	1.0
Milk, fresh	2.7	Tires, rubber	1.0
Fruits	2.7	Wood, cord, and kindling	.9
Brass, copper, and lead	2.5	Miscellaneous commodities	34.4
Beverages	2.4	Total	100.0
Textiles	2.2		

The length of haul and the average unit load of the different commodities varies considerably. Of the materials hauled 9 miles and less, gravel, sand and stone are first in importance; in the 10 to 19 mile haul they rank third in importance, and for longer hauls they are not among the important commodities. Coal appears as an important commodity only in the shortest haul groups, groceries in all haul groups up to 70 miles, and gasoline among the commodities hauled all distances up to 30 miles. The commodities of greatest importance in the long-haul groups are household goods (used), textiles, rubber tires, and crude rubber. Household goods increase in relative importance with increase in the distance hauled, constituting 5.1 per cent of the movement from 40 to 49 miles and 23.5 per cent of the haulage for distances of 100 miles and more. Rubber tires and crude rubber appear among the important commodities only for hauls of 100 miles or more, indicating the very specialized character of the movement over such long distances.

The movement of foodstuffs, consisting largely of retail distribution and the marketing of such products as milk, is predominantly a small-truck movement. Household goods are transported chiefly in trucks of 1½ to 4 tons capacity, and constitute 11.7 per cent of all goods transported in 2½-ton trucks. Gasoline is hauled largely in trucks of from 2 to 4 tons capacity, and gravel, sand stone, brick, and cement are hauled largely in trucks of 3½-ton and larger capacities. Textiles, metal products, and paper (largely news print) are also hauled in large-capacity trucks.

Truck and Rail Tonnage Compared.—Considerable data were collected as to the character and volume of freight trans-

ported by highway and railroad between selected points both within and outside of the state. The points selected represent distances varying from 17 to 140 miles, and all have direct connection by rail and highway. Between New Haven and Bridgeport 75.2 per cent of all the freight moves by motor truck, 0.9 per cent as l. c. l. rail shipment, and 23.9 as car-load rail shipment. The distance is 17 miles by rail and 18 miles by highway. Between New York City and Waterbury, a distance of 93 miles by highway and 88 miles by rail, the figures are 8.7 per cent by motor truck, 17.5 per cent l. c. l. freight, and 73.8 per cent car-load freight.

As motor-truck freight is primarily a package, or small unit shipment, it is more strictly comparable with rail l. c. l freight than with all rail freight. Of all package freight the motor truck carries over 90 per cent between points less than 60 miles apart. Between points over 60 miles apart the percentage varies considerably, but the tendency toward relatively decreasing truck tonnage with the increase in distance is very apparent.

The importance of the motor truck in the transportation of products of agriculture and products of animals is even more apparent. These classifications include a large part of the movement of perishable foodstuffs. For products of animals the motor-truck tonnage greatly exceeds the rail l. c. l. tonnage between all points analyzed except New York City and Springfield, a distance of approximately 134 miles, and exceeds the total rail tonnage between all points except New York City and Springfield, and New York City and New Haven. The large car-lot movement of these products between New York City and New Haven is largely accounted for by the fact that New Haven is the wholesale distribution market for a considerable area.

Of manufactures the motor-truck tonnage exceeds the rail l. c. l. tonnage between all points analyzed except New York City and Springfield, and New York City and Waterbury; but the total rail tonnage exceeds that of the motor truck for all distances over 60 miles and also between Hartford and Springfield, a distance of approximately 25 miles. Between the latter points, however, 3,312 tons of the total of 3,627.8 tons, or over 90 per cent of the carload tonnage of manufactures, consists of refined petroleum and its products.

The importance of the motor truck in the transportation of commodities is clearly indicated, and the data warrant the following conclusions:

1. A very considerable part of the package freight between origins and destinations in the Connecticut territory less than 50 miles apart is transported by motor truck.

2. As distance between origin and destination increases transportation by motor truck becomes of less importance.

3. The ratio of motor-truck freight to rail freight between two points varies greatly with distribution and marketing practices. Cities which are distributing points for surrounding areas receive a larger amount of freight in bulk lots, such as rail carload shipments, than cities which distribute to the local market alone.

4. For origins and destinations between which the exchange of freight includes bulk commodities, such as coal and oil, the tonnage transported by motor truck compared with total rail tonnage is relatively small. As such commodities are a necessary part of the freight into nearly all cities, motor-truck freight becomes a relatively small part of total freight.

Wayne County Concrete Roads Widened with Concrete

Extract from Last Annual Report of Road Commissioners of Wayne County, Michigan

"Our policy adopted a few years ago, of widening our concrete roads where traffic warrants, has continued during the past season.

"Eleven and one-half miles of these older roads were widened this summer.

"River Road has been widened on the west side from Trenton to Rockwood to a width of 30 ft. It is planned to eventually widen this highway to a width of 40 ft., made necessary by the fact that it is the main highway leading into the City of Detroit from the south.

The Seven Mile Road, from Livernois to Woodward Avenue, has been widened on both sides to a width of 40 ft., and on the north side only, from Livernois west to Division Road.

"All ditches have been closed and shoulders made wide so as to make this road as safe as possible for motorists.

"Warren Road, from Schaeffer Road to the new River Rouge Park, has been widened to 30 ft. on the north side only, for a distance of 3.6 miles. Traffic congestion has been particularly bad on this section, and although the ultimate width will be 40 ft., providing four lanes of travel, a marked improvement in speed of traffic has been noted already.

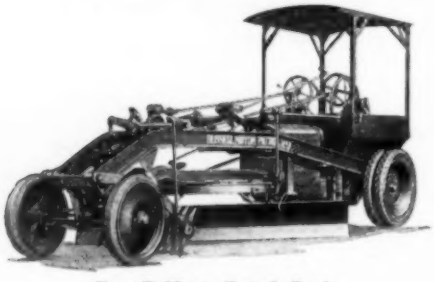
"The fact that we are able to widen the metal track after many years of use, speaks well for the type and design used at the time of construction of these roads.

"At no instance have we had occasion to completely replace the older concrete. They have withstood the intense traffic to which they have been subjected and give every evidence to many more years of use."

Motor Grader with New Features

A motor patrol grader for one-man operation, using the 10-20 McCormick Deering tractor and equipped with cab, has been developed by the Russell Grader Manufacturing Co., Minneapolis, Minn. This Russell motor patrol No. 3 has dual rubber-tired rear wheels, an independently adjustable scarifier completely controlled from the operator's platform, and a 52-in. circle which gives a wide rigid support to the blade, with a snug-fitting, sure, durable lock.

Some of the refinements found in this unit are machine-cut gears which are completely enclosed, bronze bushings and bronze collars for the worm shaft, a take-up bearing in the forward lifting arm bracket, extra large ball and socket connections in the lifting links, machined worm-gear steering control, giving an easy, steady control especially adapted to road work, Alemite lubricating throughout,



Russell Motor Patrol Grader

Timken bearings on the front wheels, a positive lateral shift of the blade, adjustable from the operator's platform, and a side cranking device.

A pressure of 4,200 lbs. is brought on the blade because the machine is built with a proper distribution of weight and with the proper balance so that no additional loading is necessary to get this increased pressure. The blade is reversible and may be tilted forward or backward from a leveling to a cutting position. Both the blade and the cutting edge are made with a special high-carbon steel highly polished, and will scour satisfactorily.

The power-plant is the well-known 10-20 McCormick-Deering tractor with forward speeds of 2, 4 and 10 miles per hour and reverse speeds of 3 and 8 miles per hour. The low speed may be used for heavy grading or scarifying work when an unusual amount of power is required. The intermediate 4-mile speed is best for maintenance work. On high, the motor patrol may be transported at the rate of 10 to 15 miles per hour. The reverse speed is frequently used by experienced operators. In filling washouts, holes, or ruts, or repairing short stretches of bar road, the motor patrol may be worked forward and backward until the job is completed, with no need of turning the machine around.

Transportation Surveys in New Hampshire and Vermont

Highway transportation surveys covering the entire States of New Hampshire and Vermont were begun on July 16 under cooperative agreement between the Bureau of Public Roads and the two State highway departments.

As planned, the surveys are to run for three months, with 13 recording parties taking data twice during the period at each of 143 stations in New Hampshire and 12 parties recording the traffic at 130 stations in Vermont.

In general the same methods will be used as in the Connecticut and Cook County surveys, reports of which have been published, and the Pennsylvania and Ohio surveys which are now being analyzed. For passenger vehicles the data will show the number of vehicles passing the station during each hour, the State in which they are licensed, the number of passengers they carry, whether the purpose of travel is business or pleasure, whether passengers are from city or farm, whether the travel is an extended tour or a short trip, the origin, destination, length of trip, and the number of miles of travel within the State.

For trucks the data will show also the number passing each hour, the State of registration, capacity, origin, and destination, with information as to the character of operation and of the consignor and consignee, the total distance of travel and mileage within the State, the commodity transported, the type of trucking (for hire, contract, hauling, etc.), and the status of ownership. In addition to this information there will be recorded at special weight stations the make of truck, type of tires, and weights on front and rear axles. Analysis of this information will make it possible to prepare maps showing the present volume and distribution of passenger vehicle and truck traffic on the highways of each of the States, from which the State highways will be classified as industrial, high, medium, or low type routes, taking into account motor-truck capacities and loads. A forecast of traffic for several years ahead will be made and a definite program of highway construction worked out. Special attention is to be given to an analysis of the relative traffic importance of the township roads with respect to the primary and secondary systems.

Economic data to be collected will include information concerning the tonnage shipped by motor truck, marketing methods, zones of truck operation, and general trucking practice.

Increasing the Safety of Highways

How the Danger Factor Is Being Eliminated from State Roads in California Described in Paper Presented at Annual Convention of the California Supervisors Association

By R. M. MORTON
State Highway Engineer of California

Improved highway construction in California has had crowded into its 15 years of intensive history, a vast wealth of experience, example and precedent as to safety details. The state and county highway builders are better able now than ever before to state in exact terms what details constitute danger in highways.

There are many details in the design of highways which have little influence on their efficiency for slow moving traffic, but which threaten the safety of the fast moving vehicle. At low speeds almost any improved highway is safe, assuming a good car and an experienced driver who has the ordinary co-relation of his senses. However, now it is for the faster traffic that we must design our highways, if we desire to reduce danger to a minimum.

The ideal highway should have sufficient width to accommodate the pavement, plus a margin of usable width to permit a car to get completely off the pavement at all points. The Motor Vehicle Act makes it a misdemeanor for a car to stop for repairs on the paved portion of the roadway, and the time is at hand when this provision should be more strictly enforced. There is no more serious menace to traffic than a car stopped on the pavement. It is an invitation to death for the persons in the car which is stopped. Many an accident has been caused by the meeting of two other vehicles at a point opposite the disabled car. At night it is doubly a menace, for it is often impossible to know quickly when approaching a red tail light, whether the car is stopped or is moving.

If a shoulder wide enough to permit of parking clear of the pavement is not provided by the road builder, the motorist is forced to stop upon the pavement.

Menace of Borrow Pits.—We now know that the high grade with deep borrow pits scooped out in the right of way is often a death trap for the motorist. So many accidents occur on account of these deep borrow pits that it is almost axiomatic in the state highway department that they are not to be constructed. Although drainage provisions are usually necessary, in country which seems to require construction by means of deep borrows on the sides, the excavation often greatly exceeds drainage necessities. When a grade is built by robbing the roadside, the drainage conditions are usually made worse instead of better, because ponds of water stand in the borrow pits, to the future detriment of the roadbed.

No road should be paved to a less width than 18 ft. Traffic on all of our public highways is now reaching a point where two lines must be provided. However, the 18-ft. width of roadway does not provide any factor of safety to permit the free, easy, and safe passage of an automobile and a wide truck or stage. The pavement is built to take the traffic, and the road builder can not assume that the driver of one vehicle should get half way off the pavement to pass a wide load. Widths of 20 ft. are considered to be necessary if we are to look a little to the future, and assume the greater use of highways which is bound to come.

Protecting Edges of New Pavement.—The junction between the firm material of a hard pavement, and the earth of the grade, is a great danger point on all paved roads, and a fruitful source of accident to the motorist. In rainy weather, if he leaves the pavement with one wheel to pass a vehicle, he sinks into the soft slippery shoulder, then endeavors to climb back by a quick turn on the steering wheel. Sometimes he goes across the pavement into the other traffic lane, thereby endangering the lives and property of those using that side of the road. Many accidents occur on low soft shoulders by the car overturning before its wheels climb back to the pavement.

This is a situation which road builders should not tolerate and can do much to prevent. It is the endeavor of the state to protect the edge of all new pavements by an additional two feet of crushed rock. The purpose of this is to widen the usable hard surface, as well as to create a transition area, the outside edge of which will not be so rigid or so abrupt as the edge of the hard pavement.

A good means of keeping traffic of the shoulders of the highway is to supplement with rock the width of the pavement and to

permit vegetation to grow on the sides. It is noticed that motorists are much more careful to keep off the grass than off smooth appearing earth shoulder. This reduces maintenance expense and at the same time it increases safety by encouraging more careful driving.

Curvature and Superelevation.—Curvature in road alignment has ceased to be a pet of the engineer, used by him only to cause right of way difficulties for the supervisors. The motoring public has become educated to the difference between a 100-ft. radius curve and 300, 500 or a 1000 ft. He knows there are certain bad bends which require reducing his average speed to one half, and that there are others around which he can travel without slackening. He appreciates the safe curve. A highly superelevated curve of 300-ft. radius is about the minimum which the average driven car can safely negotiate at a speed of 35 miles per hour. The center of a 300-ft. radius curve at a right angle corner will lie about 125 ft. from the intersection of the two straight lines. A 500-ft. radius curve will lie about 200 ft. in from the intersection of the two straight lines.

When first considered, the idea of taking valuable property just to ease up a corner for the speeding motorist may seem unreasonable, but these and even more drastic lines are necessary to build real safety into the roads. If the highway is to be paved, there will be an actual saving in length of pavement by installing a 500-ft. radius curve instead of building a right angle of over 200 ft. in length. At $4 per lineal ft. for the pavement, this amounts to over $800 saving in cost of paving construction, which can be devoted to procuring the new right of way. On a curve of 1000-ft. radius in such a location, the difference in length of pavement would be over 400 ft., which at the same rate would permit of $1,600 being devoted to procuring new right of way.

Superelevation is another semitechnical term loved by the engineer and by the motorist. It means simply the banking, or raising of the roadbed on the outside, to make the car lean to the inside as it passes around the curve. Combined with the force of gravity and the centrifugal force, a properly banked curve keeps the center of gravity of the car properly spaced between the wheels in contact with the roadbed. Railroad tracks are laid out with superelevation on the curves, thereby permitting high speed trains to take them without slackening speed.

The necessity of superelevation, as a safety measure on the public highways, is now a well learned lesson.

Importance of "Sight Distance."—The term "Sight Distance" denotes the distance which the motorist traveling on the right side of the road can see past an obstruction, to sight an approaching car. Human beings differ in their time of recording sensations on the brain and getting the muscles into action. Some drivers are slow in their reflexes. A car moving at 30 miles per hour travels 44 ft. in one second; at 40 miles per hour it travels 50 ft. in one second. Assuming that two cars are approaching each other at 30 miles per hour around a curve, the distance between them is lessened by 44 ft. in one second for each car, or at a combined rate of 88 ft. per second. Therefore, with a sight distance of 88 ft. on the curve, there would be one second for the senses of the drivers to act, for the muscels to act, and for the vehicles to respond and pass safely. Any such small distance is entirely too short to permit of a speed of 30 miles per hour. The average driver will require one second to adjust himself, one second should be allowed for the vehicle to respond, and there ought to be one second to spare. Therefore, a sight distance of 300 ft. is the minimum which can be considered really safe. Even around curves from which obstructions have been removed to make a sight distance of 300 ft., speeds greater than 30 miles per hour are hazardous. Sight distances must be increased to 400 or even 500 ft. in order to permit of safe travel at a speed of 40 miles per hour.

Sight distance also comes into the calculations of the road builder on vertical curves, where two cars will approach the crest of a hill from opposite sides. In such cases curvature should be such that there is as long a sight distance as possible. To pass a vehicle going in the same direction when approaching the crest of a hill is always dangerous, until the driver has a clear view of the road ahead over the top of the hill. Good practice requires that the crest of the hills be lowered by means of long, flat vertical curves.

The Grade Crossing Problem.—The problem of railroad grade crossings has consumed the time of many committees during the past few years. The grade crossing catches good and poor drivers alike. There is only one safe rule for the motorist in approaching a grade crossing, that is, to slow down to a speed which permits him to carefully look in each direction when still at a good distance who does not take this common sense precaually that a train is not approaching. Warning signs, bells, human flagmen, wigwags, and even traffic gates do not protect the motorist who does not take this common sense percaution. We sometimes say that he kills himself, but that does not repair the loss sustained by society when a carload of passengers is wiped out in an instant. The railroad com-

mission of this state has adopted a policy of refusing to open grade crossings except when another is closed.

There is one good rule for the highway builder, and that is, to never improve a highway at grade across a main line railroad. If the highway is worth building, it must be because of the amount of traffic, and if the amount of traffic justifies building the highway, it usually justifies going a little further and planning a grade separation to be constructed along with the highway project.

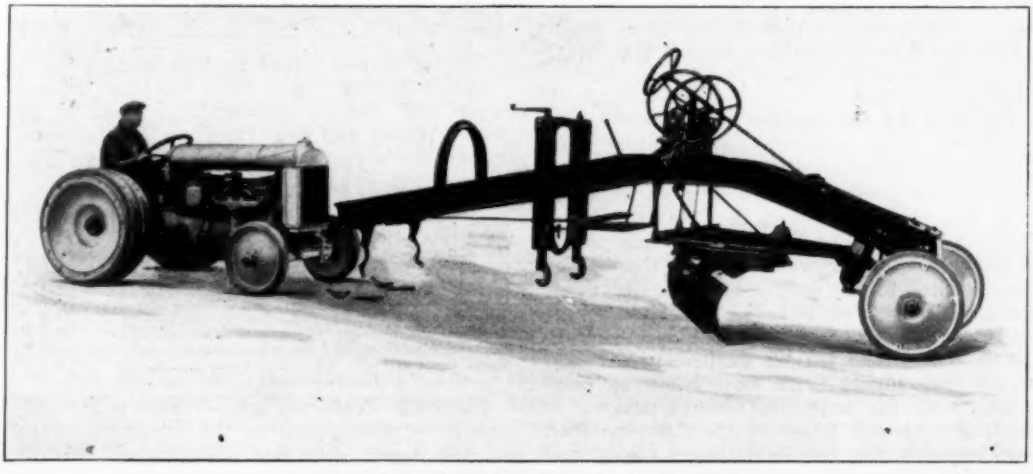
The practice which has become fairly standard in California is to assess one-half the cost of the project to the railroad, the other half being borne by the public. Although this phase of highway work is expensive, and adds to the number of major structures which must be built, there is nothing which is more appreciated.

The points above enumerated, which make for safety, have to do entirely with the designing and building of the road. They include the width of grade and pavement, the avoidance of death trap borrow pits, treatment of the shoulders, the alignment of the road, superelevation of the surfacing, sight distance on curves, and railroad separations. If a highway is well laid out with due attention to all of these details, the road builder has gone far in safeguarding the user of the highway. There are additional minor safety measures, the need for which should be studied by the road builder after the highway is in operation. These are improvements or betterments of a minor nature, which contribute added safety for fast traveling motorists.

One very important measure, which is highly conductive to safety, is the center guide line, which divides the pavement into traffic lanes. This is a great help to the motorist, both day and night, for it marks off a certain width for his exclusive use, and he proceeds with the assurance that the approaching motorist, desiring similar courtesy, will not encroach upon his side of the road. Workmanlike guide lines are not easily installed. White paint makes the best guide line on either cement or asphalt surface, at a cost of from $40 to $50 per mile. Black guide lines of asphalt can be installed for $10 per mile or less, where there is much of it to do.

Quick Detachable Grader for Fordson

A quick detachable grader for the Fordson, using the one-unit principle has been added to the line of the Wehr Co., Milwaukee, Wis. It is a very complete one-unit power grader of the same principle as the original one man Wehr. By detaching the Fordson tractor from the quick detachable Wehr, the tractor can be used for other work to which the grader cannot be adapted. The installation of the quick detachable Wehr grader on the Fordson tractor is stated to require only from 5 to 15 minutes time. The one-unit principle of the Wehr fully utilizes the tractor's weight. This weight, added to the grader, produces more pressure on the blade, making it possible to cut off the high hard spots, instead of riding over them. The weight of the grader adds efficiency to the tractor, increasing traction and power. The quick detachable Wehr is built as husky as the standard model Wehr grader. The same front cross bracings which tie the grader frames together and make the grader perfectly rigid, are used in the Q.D. Model. They are held together at the back by a cradle bracing which also helps to hold the grader rigid and entirely eliminates frame bending.



Model Q.D. Wehr Grader With Tractor Detached

New Type Flat-Spoke Tractor Wheel

One of the latest developments in flat-spoke tractor drive wheel construction is that manufactured by French & Hecht, Davenport, Ia., and Springfield, O.

Outstanding features of this wheel are the flat spokes, so formed at the ends as to be forged while hot into the hub and through the tire, and the flanged and grooved light-weight tire.

The typical French & Hecht flat-spoke tractor wheel, illustrated herewith, has a diameter of 46 in. with a tire 12 in. wide and ¼ in. thick. There are 18 spokes, each having a cross-section 1½ by ⅝ in. The arrangement of the spokes is staggered, the two rows being 3 in. apart in the tire and 7 in. in the hub. Spoke ends that pass through the hub flange and tire are round, the cross-sectional area at the round part being larger than that of the flat section. In forming the spoke ends, therefore, the metal is slightly upset.

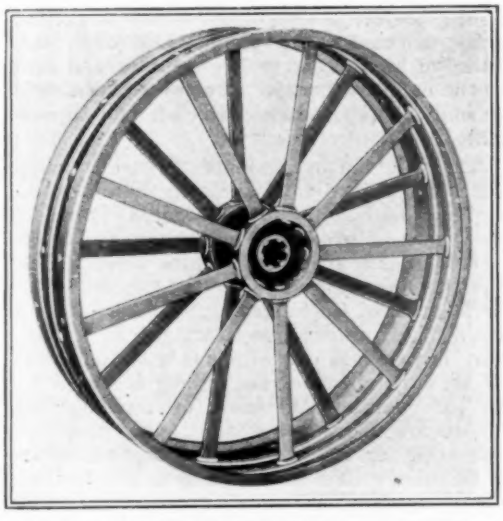
A distinctive feature of these wheels is the fastening of the spokes at the hub and tire. The steel spokes are forged while hot into the hub, and have heads formed on the inside of the hub and shoulders on the outside. This produces a spoke fastening similar to that of a boiler rivet. The spokes are firmly headed and shouldered into the tire, and as they are in a trussed position (not straight) a wheel is produced that is light in weight, yet very strong and sturdy.

Added strength, without excessive weight, always an important consideration in tractor service, is gained by a light-weight tire having the edges flanged inward, and two grooves near the middle. The grooves give an additional stiffness to the tire, and at the same time provide protection for the spoke heads. This is an advantage, whenever the tractor is used on hard roads. Having the spoke heads below the face of the tire allows the cleats and grousers to be spaced in any desired positions.

Flanging the tire enables the makers to construct the wheel much lighter in weight than would obtain with an ordinary flat-bar tire.

The general design of this new wheel is that it is built up around the live axle drive. The hub is splined to fit the splined axle shaft. Because the flat or wide sides of the spokes are parallel to the edges of the tire, great strength is provided to take care of the severest torque loads, from the engine. Placing the spokes in the trusses position takes care of all side thrust loads that come so commonly. As for example, when a tractor is plowing with one wheel in the furrow, when working on a side hill, or pulling a heavy load on a sharp turn.

The shape of the spokes is such that strength is placed at such points as most needed. At the hub end of the spoke the shoulder and tenon are so designed as to add strength to the point on the spoke a short distance from the hub. There is a very liberal fillet that extends up the spoke, and the large shoulder anchors the spoke in the direction of the torque load, as well as sideways. The forged spoke heads are large in diameter to match the large shoulders. Thus the spokes are very rigidly and stiffly attached at both the hub and tire.



French and Hecht Flat-spoke Tractor Wheel Has a Flanged and Grooved Light-weight Tire.

This type of wheel is built in all sizes, with various numbers of spokes, and with the required stock sizes of spokes and tires to meet the requirements of the many types and sizes of farm and industrial tractors.

Cost of Street Oiling at Waltham, Mass.

The following table from the last annual report of George C. Brehm, Director of Public Works and City Engineer of Waltham, Mass., shows the cost of street oiling in that city in 1925.

Square yards treated	544,120
Miles treated	51.6
Oil applied, gals.	83,596
Oil per sq. yd., gal.	0.154
Cost of oil, per gal.	7.1 ct.
Cost of applying, per gal.	5.3 "
Total cost per gal.	12.4 "
Cost of oil, per sq. yd.	1.1 "
Cost of applying, per sq. yd.	.8 "
Total cost, per sq. yd.	1.9 "

Sidewalk Traffic Police.—Traffic police officers have been placed on the sidewalks in one of the main shopping districts of Rio de Janeiro.

Road Construction Abroad

Information Regarding the Highway Systems of Various Foreign Countries

Shortly after the Highway Section of the U. S. Bureau of Foreign and Domestic Commerce was formed in August, 1925, requests were sent to all foreign representatives of the State and Commerce Departments for reports on the highway systems of their territories, The following information taken from the various reports received to date is given in a special circular issued last month by the Transportation Division of the Highways Section:

Australia

New South Wales.—The total mileage of highways is 104,764, classified as follows:

Controlled by	Metalled, graveled, ballasted	Formed only	Cleared only	Natural only	Total
National	40	16	2	.....	58
Municipality	4,772	1,787	1,859	1,589	10,007
Shires	18,369	13,745	27,216	29,374	88,704
Western Division	173	147	3,435	2,240	5,995
Total	23,354	15,695	32,512	33,203	104,764

About two-thirds of the main highways of New South Wales are fairly good for motor traffic except in the rainy season. These roads, however, are being improved gradually. The Australian government will pay a subsidy of £115,000 annually for the construction and improvement of roads in this state. Other funds will be obtained from the revenue and loan appropriations made by Parliament. The government will be responsible for half of the interest and sinking funds on loans raised for main roads. The market for road machinery and equipment is not a growing one, because of the small population and lack of proper appropriation for the purchase of equipment.

Tasmania.—In 1924 there were 53 miles of roads cleared and 48 miles metalled. The work is carried on by municipalities, while the cost of construction is borne almost entirely by the central government. On July 30, 1924, the loan expenditures on these works were £3,903,835.

Queensland.—The road mileage of this state is not obtainable at the present time. The main roads are designated primarily to assist producers in getting products to the railways. The roads in the western part of the state are of good sandy loam. The highways are controlled by the Commissioner of Main Roads and by the local authorities concerned. The principal cost of construction and maintenance is borne by the State, though some assistance is secured through Federal grants. Small funds are contributed by the Auto Club of Queensland for placing certain roads in good condition.

Victoria.—The extent of good roads is not large, but is steadily improving. There are no figures to show the number of miles under construction. There are a few roads with concrete surfaces, and not many surfaces of macadam, but on the whole the roads are fair. Most of the roads in the mountains are well graded and steep climbs are exceptional. The construction work is done by the shire councils and municipalities. The Victorian County Roads Board has control of the roads. Expenditures on the construction of roads amounted to £3,256,911 during the past year. The local representatives of American manufacturers of machinery state that competition from Australian firms, aided by a substantial tariff protection, is reducing the market. It is said that Australian firms wish American firms to send some first class foremen with American-made plans to share in their work, thus combining the two firms. If this is not done the Australian firms would copy American machines and sell alone. The local representative thinks that it would be best to co-operate with these firms.

Western Australia.—There are approximately 40,000 miles of roads in this territory, which are controlled by the District Road Board. Of this amount 5,000 miles are graveled, 7,000 miles cleared and formed, and the rest are merely plain, unimproved dirt roads. Approximately 1,200 miles of these roads are controlled by Municipal Councils. The construction of roads is carried on mainly by contract. The cost of construction varies from £1,000 per mile in the dry area to £2,000 per mile in the wet area. All road machinery is purchased through the Government Tender Board by means of inviting tenders. Most of of the machinery and equipment is of Australian manufacture. The funds are raised by local governing bodies, who have authority to borrow money for roads. The state also makes special grants.

Belgium

The total length of roads is 10,000 kilometers, practicable for automobiles at all times. There are very few roads under construction, as nearly every place in the country has road connections. However, all roads are in need of repairs. There is no money at present for repairs to roads, and the cost of keeping the road system in good condition would amount to 80,000,000 francs annually. In 1923-24-25 from 24 to 26,000,000 francs were spent yearly.

Funds for road construction and upkeep depend entirely upon the ordinary Government and Provincial budgets. There are also special taxations which go to the fund. Very little road machinery is used in Belgium. The road system is under the Central Government and partly under Provincial administration.

British East Africa

There are approximately 16,098 miles of roads in British East Africa, half of which are not passable at certain times of the year. New roads may be constructed in Kenya to Coastal East Africa. Development will probably take place in the next few years, but it will be some time before sufficient funds can be obtained for road construction.

Canada

British Columbia.—The road system of this Province is 17,200 miles in length. The roadbeds vary from 14 to 18 feet. The mileage of roads passable throughout the year depends entirely upon the winter. There are 250 miles under construction and 250 miles projected, while it is possible that in the next ten years 5,000 miles of new roadway will be constructed. The construction of roads is done partly by hand labor. All paving is done by contract. Very much machinery is used in this province. The Department of Public Works controls all roads in unorganized districts, and also controls the Primary Highways. The secondary roads fall under control of the municipalities.

Manitoba.—The total mileage of roads in Manitoba is 1,600. Of this amount 368 miles have been graded and 432 graded and graveled. Road making in the past has not kept pace with the progress of the times, but in 1925 it advanced more rapidly than any other time in the history of the province. All funds for road building and repairing are paid by the Legislature. The government is to take over the work and considerable progress is expected.

Ontario.—There are 67,786 miles of roads in the province; 36,153 being passable the year around. The construction and maintenance is carried out by the Provincial Department of Highways, counties and townships, as well as the Provincial Department of Northern Development. Construction is done only by contract with private firms. The same machinery that is used in the northern part of the United States is used in Ontario and the bulk of it is imported from the United States. Up until 1925 the roads of Ontario had cost $111,522,492. The total value of contracts awarded was $4,000,000 during the past year.

Quebec.—The total length of roads in Quebec is about 40,000 miles. The 1925-26 budget calls for $6,500,000 to be spent on roads, while the budget for the next fiscal year will probably be about $5,000,000. From 1911 the amount spent to date is $68,000,000. All work and repairs are done by contract, while the Roads Department is well equipped, with some of the machinery imported from the United States.

China

In Northern China, where building is easy and where rapid transportation is urgent, motor roads are gradually being constructed. The International Famine Relief Commission has built about 1,800 miles of roads and the American Red Cross about 850 miles. All of these roads are in fair shape and can be used the year around.

Hankow.—The roads of Hankow are in bad condition with the exception of 30 miles of foreign concessions. All of the roads are impassable during the rainy season. Good roads, with the exception of imperial highways, have been unknown to the Chinese. The roads already built were constructed by military officials. The development of China, it is said, depends largely upon the road system.

South Fukien.—There are only 107 miles of road suitable for motor traffic, with 82 miles under construction. One hundred and two miles are being planned for future construction. Practically all of the roads completed can be used during all the year, except for a short time during the rainy season. The roads are in very bad condition compared with those of other countries and are in constant need of repair. Most of the work is done by local private contractors, while a little is done by military authorities. There is no market for road machinery at the present time, nor will there be any until the return of normal conditions.

Czechoslovakia

There are only a small number of good roads in this country, the majority of these being confined to Bohemia. However, there are many roads which, though not so good, are passable throughout the year. Only a few roads are under construction at the present time owing to the lack of funds. The budget for the current year calls for the building of 26 kilometers at a cost of $240,000. No other work is contemplated for the immediate future, although the government realizes the necessity of more roads and is trying to borrow money for this purpose. The government sees that all roads are kept passable. Very little machinery is used because of cheap and abundant labor. Prospects for future sales are not very bright.

Ceylon

In Ceylon there are approximately 4,000 miles of good motor roads. The roads passable all year total 4,250 miles, while in dry weather

there are about 5,400 miles. There are no figures to show the number of miles under construction but it is known that the Public Works Department is constructing 180 miles and has also planned for 106 miles. There are no concrete roads in Ceylon. All of the principal roads are constructed by the Public Works Department of the Ceylon Government. Very little machinery is used as labor is plentiful and cheap. Most of the machinery bought is of British manufacture, bought by the Ceylon government.

Dominican Republic

There are nearly 700 kilometers of first-class roads in this country, with 200 kilometers under construction. One thousand kilometers are to be constructed as soon as funds are available. Appropriations for road construction are made exclusively by the National Government. All money and labor is under the supervision of the officials of the Provinces and Communes. A law of the Republic compels every male citizen between the ages of 16 and 60 to work on the roads four days in the year or pay $1.00 per day for hired labor or the purchase of material.

India

Burma.—Burma has a road system of 18,647 miles in length. Of this amount there are 2,127 miles of metaled roads. The standard width of the roads is 16 ft. Communication by road between the cities of this country is not practicable and roads are impassable during the monsoon period. The construction of highways has been more retarded in Burma than in any other province in India. The chief cause of this is the lack of funds and an insufficient personnel to supervise the work. A sum is set aside each year for the road system, but no special revenues are raised for the road system. The annual sum spent since 1920 has been £2,159,000. The Public Works Department of the Provincial Government maintains approximately all of the roads. There is no market for machinery and prospects for the future are not very bright, on account of the cheap labor which is sufficient for the present program.

Madras District.—Of the 27,350 miles of roads in this district, approximately 20,350 miles are considered passable at all times, the rest being affected by rain at certain times of the year. All of these roads are in a fairly good condition. There are at present 200 miles under construction, with 100 miles being projected. The government allots the sum of rupees 500 per mile each year for the upkeep of trunk lines with the Presidency and rupees 1,000 per mile each year in the case of such roads within various districts and municipal corporations limits. This includes minor repairs on bridges and culverts. All roads are maintained by the Public Works Department of the Government, District Boards, and Municipalities. Rupees 755,402 were spent during the fiscal year ended March 31, 1925. Most of the road material is supplied by American firms at the present time although the time allowed after bids are called for is too short for American concerns. With more roads under construction there should be an increase in the sale of American materials.

Bombay.—There is only a fair amount of roads in this district, but much progress has been made during the recent years. A large number of the roads are metaled and can be used during the entire year. The road construction and administration of the native states is carried on by their rulers. The Public Works Department of the Bombay Presidency has charge of all of the primary roads of the province. Very little machinery is used and all small purchases of machinery and supplies are made through the Chief Engineers of each province, while all large and expensive material must be applied for to the Chief Controller of Stores, Government of India, Simla. All purchases are made in England, if possible. Foreign firms must have their names registered and put on an approved list by making direct application to the Chief Controller of Stores, Indian Stores Department, Government of India, Simla.

Calcutta.—The number of miles of roads passable during the year is 19,322, while there are 83,658 miles passable in dry weather. There are 69½ miles now being projected. Because of the monsoon most of the roads are flooded during part of the year. The estimated cost each year for provincial roads is 640 rupees, and 470 rupees per mile for local roads. All of the highways are constructed and maintained by Government or local municipalities. When a road is to be constructed an estimate of the entire cost must be submitted to the Government. The Government then invites firms to submit their bids. The road building machinery is limited to a few steam rollers and scarifiers, all stone being crushed by hand. There is no growing market at present for road machinery.

Karachi.—In the Karachi district there are 31,811 miles of roads in addition to a large number of by-roads and paths maintained by local District Boards. Most of the main roads are passable throughout the year except when snow or rain is exceptionally heavy. The roads of this district are divided into four categories as follows:

(a) Civil Roads, maintained from civil funds voted by the Central Legislation at Delhi.

(b) Civil Roads of Military Importance which are financed jointly by military and civil departments. The civil contribution being provided by the Government of India from non-voted resources.

(c) Military Roads, such as those in cantonments and stations or required for purely military purposes, which are financed from military sources entirely.

(d) District Board Roads which are financed from funds provided by local bodies. Civil funds are administered by Secretary to the Chief Commissioner in Public Works Department and are allotted by him to the Military Engineering Service, which are the executive agency for carrying out all works, both civil and military, in the province. Very little machinery is used.

Ireland

Of the 15,265 miles of roads in Ireland only 500 miles can be called good motor roads. About 10,000 miles are passable for automobiles at all times of the year and 13,000 miles in dry weather. The roads are constantly being resurfaced and repaired continuously, with very little machinery being used. The government supplies the funds for road construction and maintenance while all roads are under the supervision of the county councils.

Portugal

There are 13,500 kilometers of roads in this country, with 4,500 almost impassable. The annual allowance for roads is 21,000 cantos but the government purposes to contract a loan of 400,000 cantos to be used exclusively for roads.

France

Somme.—In the Somme district there are 2,796 miles of roads, all of which are considered passable at all times of the year. At present there are no new roads under construction as the system is considered sufficient for the traffic. Roads of this district were badly damaged during the war, but repairs were rapid and the roads are now in fine condition. The Central Government has control of all of the national roads, while the Service Vicinal has charge of all others.

Pas-De-Calais.—The national highways in this district total 683 kilometers, local or commercial 5,150 kilometers, and ordinary or commercial 4,965 kilometers. All national or local highways are passable at all times of the year with the exception of a few days when the snow or rain is exceptionally heavy. About half of the other roads are not available during the winter or after heavy rainfall. No new roads are being constructed or planned for the near future as the present system is considered sufficient for the traffic. Construction and maintenance is done exclusively by the French Government.

Eure.—Roads are divided into four classes, viz., National, Departmental, Cantonal, and by-roads and lanes. There are 291 miles of National roads and 2,135 of Departmental. All roads are passable throughout the year for automobiles. No new roads are at present under construction. Due to the mountainous territory and rain the roads are generally in bad condition. National highways are under control of the Chief Engineer of the Ponts et Chaussees at Evreux and the departmental and lesser roads are under control of the Service Vicinal at Eureux. Roads are administered and financed either by the French Government or, in the case of lesser roads, by the Departmental Government. Foreign made road implements are seldom used in France. French manufacturers are well protected by a tariff.

Seine.—There are 6,773 miles of roads in the Seine district. All roads are passable throughout the year and 5,095 miles may be classed as good roads. No new roads are being constructed but old roads are being improved and widened. The Service Vicinal prepares projects for construction, maintenance or improvements, the work being done by contracts. Steam rollers are the only road machinery used.

Siam

Highway construction has played only a minor role in the development of the country. Roads are all short and are not in a good condition. The Department of Ways of the Ministry of Communications of the Siamese Government controls all roads of any importance. Many of the roads are not passable during rainy season, a few being passable the year around. No new roads being constructed at present. All roads of any importance have been constructed and maintained by the government. With the exception of steam rollers little machinery is used.

Straits Settlements; Federal Malay States

Roads are generally in an excellent condition. There are 780 miles of roads in the Straits Settlements, and 4,542 miles of road in the Malay States. Large sums are spent annually on roads. It is doubtful if any other tropical country has a better road system. All road work is done by the Public Works Department of each state. All bodies under Government control must purchase machinery whenever possible from British manufacturers.

Tunis

As in all French Colonies, the roads of Tunis are generally good. Roads have suffered much

since the war on account of the heavy traffic. Motor roads passable all year are 4,000 kilometers in extent, those passable in dry weather 6,000 kilometers. Two hundred kilometers of roads are under construction and 1,500 are projected. Beginning January 1, 1926, construction and maintenance of roads will be administered by a special organization, "Office des Routes." Administration of all roads in Tunisia is federal. American exporters should find market good on account of the determination of the Government to construct more roads.

Uruguay

Uruguay has 8,262 kilometers of roads, classed as follows: National, 3,462; Departmental, 4,800. Of the total 435 kilometers are good paved motor roads, 746 kilometers are passable all year, and 72 kilometers are passable for automobiles in the dry season. Other roads are gradually being improved. The Minister of Public Works is in charge of roads.

Great Britain

CLASSIFICATION OF ROADS, 1925-26
Schedule of Mileage

	Miles of Roads	Mileage Class I	Mileage Class II
England and Wales:			
Administrative Counties (excluding County Boroughs and London)—			
Main	29.573.56	16,402.83	7,038.04
District	110,468.19	1,103.38	3,794.61
Total	140,041.75	17,506.21	10,832.65
County Boroughs	10,955.33	1,216.52	555.87
Metropolitan Boroughs and L. C. C.	2,201.15	249.55	122.64
Total (England and Wales)	153,198.23	18,972.28	11,511.16
Scotland:			
Counties	24,029.52	5,192.27	3,369.11
*Burghs	977.85	164.02	49.73
Total (Scotland	25,007.37	5,356.29	3,418.84
GRAND TOTAL	178,205.60	24,328.57	14,930.00

*The burghs of Aberdeen, Dundee, Edinburgh, Glasgow, Greenock, Motherwell and Wishaw and Paisley

All funds for roads are under the control of the Ministry of Transport.

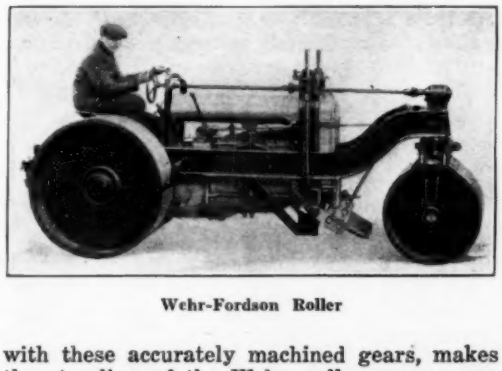
3, 4 or 5-Ton Road Roller

By an ingenious arrangement for bolting heavy discs to the wheels, the Wehr Co., Milwaukee, Wis., has produced a Fordson road roller which can be made a 3, 4 or 5-ton machine. Discs bolted to the rear wheels make it a 4-ton roller; to front and rear wheels produces a 5-ton machine. Actually the parts of the Wehr roller are stated to be heavy enough for a 6 or 8-ton unit.

In addition to this variation in weight, the Wehr engineers have located the scarifier ahead of the center of gravity. Thus the pressure required to force the teeth into the ground, and the pressure required to keep them there, does not lessen traction by lifting up on the drive wheels. By pushing the lever at the right side of the tractor, the scarifier drops to working position. The hand wheel at the operator's left gauges the depth of the teeth. The scarifier attachment on the Wehl roller is optional equipment.

The frame of the Wehr-Fordson road roller is 8 in. channel steel, and a 3-in. diameter steel shaft is used in the front axle. The front wheels are mounted on four bronze bearings. The kingpin is a 2½-in. diameter steel shaft, and the cast steel pilot is mounted in heavy bronze bearings. This pilot is 11½ in. long; it is tapered from 4 in. in diameter at the bottom to 3 in. in diameter at the top.

The steering worm is made of steel, with machine cut teeth; the steering worm gear is also machined steel. A 120 to 1 ratio along



Wehr-Fordson Roller

with these accurately machined gears, makes the steerling of the Wehr roller very easy. When the scarifier is used, the Fordson front end is spring mounted.

The Wehr-Fordson roller is 12 ft. 4 in. long and 5 ft. wide; the total height without top is 5 ft. 7 in. It has a 9-ft. wheelbase; the width of front and rear rolls is 16 in. Diameter of rear rolls 42 in. and the diameter of the front rolls 30 in.

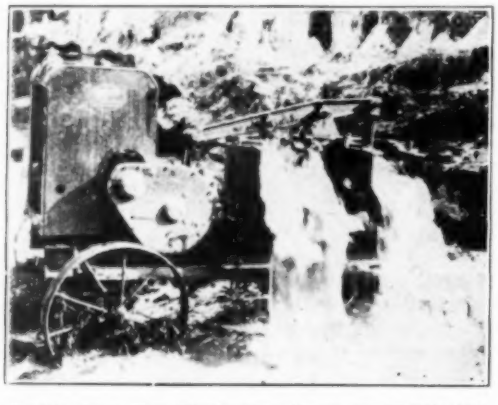
The compression on the rear rolls per lineal inch on the 2-ton is 110 lb.; 4-ton, 154¾ lb., and the 5-ton, 200 lb. On the front rolls, the 3 and 4-ton are 95½ lb, and the 5-ton, 115 lb.

There are seven teeth in the scarifier; 4½ in. between the teeth, 7 in. ground clearance when raised, and a 6-in. vertical adjustment of the teeth.

Municipal Tourist Camp at Denver Pays.—In 1925, 79,433 campers in 23,558 automobiles visited the Denver municipal auto camp from whom the city collected $14,700 in fees.

New Pumping Outfit

The illustration shows the new pumping outfit developed by the Novo Engine Co., Lansing, Mich., the first of the year, at work on a job of the B. & P. Construction Co., Sarasota, Fla. The Novo rating of this pump is 16,000 to 20,000 gal. per hour, total head 20 ft. Closed top force diaphragm pump (double) similar to the double open top diaphragm pump shown has the same capacity. The total head at which the closed top pump will operate is 50 ft. The power unit is the UF, 3-6 HP two cylinder, Timken tapered roller bearing engine. This engine, also brought out the first of the year, utilizes an opposed throw counterbalanced crankshaft; the drive shaft (gear driven from crankshaft through power gears—not timing gears) and crankshaft run in Timken tapered roller bearings. To reduce the engine speed, to a slow reciprocating motion, an enclosed speed reducing unit, with crank arm is employed. This unit, designed for use with the Novo UF engine, is enclosed and dirt proof. Gears run in a bath of oil. Babbitted adjustable bearings are used. Drive shaft pinion and speed reducer gear also run



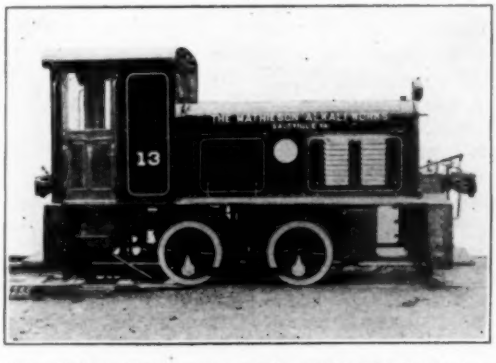
Double Open Top Diaphraghm Pump on Florida Job

in oil and are enclosed in a gear case. The line rubber diaphragm with which this and other Novo diaphragm pumps are equipped are stated to operate, under normal conditions, from 150 to 200 hours.

Traffic Lines on Wide Roads.—The Road Commissioners of Wayne County, Michigan, have adopted the practice of marking two or more lines on roads 25 ft. or wider, thus making three or four lanes of travel. This has had the desired effect of keeping traffic to the edge of the road, allowing other vehicles to pass in the center lanes. When but one line was marked on these pavements, traffic spread all over the pavement and the extra width was not utilized to the fullest extent.

Improvements in Vulcan Gasoline Locomotive

The Vulcan Iron Works, locomotive builders of Wilkes-Barre, Pa., is now prepared to furnish its gasoline locomotives in all sizes from 8-tons up equipped with elliptic springs and cross-equalizers, giving three-point suspension of the chassis. With this design derailment is



8-Ton Vulcan Gasoline Locomotive With Elliptic Springs and Cross-Equalizers

stated to be a rare occurrence inasmuch as the weight of the locomotive is always equalized on all the bearings regardless of any unevenness or irregularities in the track. Three-point suspension is standard practice on all steam locomotives. Vulcan electric locomotives are of this design, and the heavy Vulcan gasoline locomotives (from 16-ton up) have always been so constructed. Among those who have already purchased Vulcan gasoline locomotives with 3-point suspension are the Mathieson Alkali Works, Canada Cement Co., Albany Crushed Stone Corp., Bethlehem Steel Co., National Tube Co., International Motor Co., Gary Tube Co., Utah Iron Ore Corp., St. Lawrence Paper Mills, E. B. Eddy Co., Stone & Webster, Inc., the Arundel Corporation, Bates & Rogers Construction Co.

Detecting Teredo by Sound Amplifiers.

At the suggestion of Searcy B. Slack, Bridge Engineer of the Georgia State Highway Department, the Bell Telephone Laboratories in cooperation with the laboratory of the Georgia State Highway Department, have constructed several types of stethoscopes, which were used this summer in attempts to detect the presence of teredo in timber and piling. A scheme of poisoning teredo also will be tried. It consists of surrounding the pile with a canvas envelope and applying a dose of poison to the small amount of water between the envelope and the pile.

Field Control of Highway Construction

Organization and Routine of the Michigan State Highway Department Described in Paper Presented at 12th Annual Conference on Highway Engineering at the University of Michigan

By C. E. FOSTER

Construction Engineer, State Highway Department of Michigan

Field control of highway construction in the state highway department consists of arranging the construction organization and facilities of the department in a manner such that the work under construction will be uniformly built, throughout the state, in accordance with the plans and specifications. It further consists of recording such features of the construction as effect the strength and utility of structures, road bed and surface in a manner that will facilitate the intelligent study of the completed project in actual service with a view to securing more economically and correctly designed highways. To carry out these objects successfully and secure the results desired on a program of several hundred projects scattered over the state, it has been necessary to work out an organization and routine for handling the work which, to those not familiar with the magnitude of the undertaking, may seem quite involved.

How the Organization Has Been Built.—The organization of the department as it effects construction has been built up on the theory that state wide uniformity of construction can best be secured by maintaining at headquarters, a strong central office composed of men fitted by experience to lay out the work before construction, and administer it after it has been put under contract. Thus, surveys, plans and design of structures are handled in the Lansing office under the direct supervision of division heads who are held responsible for the work in their charge.

The field work is under the direct supervision of a construction division composed of resident engineers, who are in charge of groups of counties, and project engineers directly to the projects under construction.

The contact of office with field is made through division engineers, who, in a sense, are the direct representatives of the office in the field. By close co-operation between these men and the office division heads, it is possible for the central office to keep in close touch with the field work at all times. This arrangement is very desirable, because the successful control of the work in the field is affected in a large measure by the proper preparation of plans and specifications.

The Routine Work.—The routine which has been worked out for the preparation of plans is under the direct supervision of the engineer of design who personally supervises the important features of this work. When preliminary work has been completed, the plans are taken into the field and checked on the ground by the engineer of design or one of his assistants, in company with the division engineer or resident engineer who is to have charge of the work. Every possible contingency that can be anticipated at this time is carefully studied in detail and provided for on the plans. This system reduces the number of changes in plans during construction which might be caused by plans not so carefully prepared. It also gives the field engineer an opportunity to study the job with plans in hand prior to construction, and helps to familiarize him with the work contemplated.

The specifications for the work also effect greatly the control of the work in the field—in fact, the specifications together with plans are intended to completely control the results expected from the contractor. In order to eliminate unnecessary friction between the contractor and engineer during the progress of the work, the specifications should be definite in their requirements so that the work contemplated will be fully understood. The success of the work depends upon co-operation between the construction organization and the contractor, and, if a business basis for their dealings is provided by specifications which are obviously fair to both parties to the specifications have been rewritten from time to time and it has been the object of those having this work in charge to make them as clear and definite as possible in order to accomplish this end.

The control of the construction work in the field is carried out through the field organization and the highway laboratory. The routine for carrying it out may be divided into preliminary field work, instrument work on construction, inspection of work in progress, routine reports and construction records. Following is a brief description of the work as it is handled in the department.

How its Work Is Handled.—After the con-

tract has been awarded, the resident engineer and project engineer, go over the job in detail with the contractor and secure from him a proposed outline of his operations, including his plant lay-out, force to be employed and other items affecting the conduct of the work. The progress schedule for the job is reviewed at this time to see that the contractor's plan for conducting the work will satisfy the requirements of the contract in this respect. After this has been done, the resident engineer goes over the job again with the project engineer and together they lay out the engineering work so that adequate service will be provided the contractor in the way of setting stakes and inspection of materials and workmanship.

The project engineer is required to set slope stakes for all grading operations in advance of the work and at the time of setting the slope stakes, he is also required to cross-section the work as a check on the original survey. As soon as the rough grading has been completed, the engineer is required to set shoulder stakes for the finishing of the grade. Likewise stakes must be set for the surfacing operations. This work is done well in advance of the contractor's operations so he is not delayed by a lack of stakes. The instrument notes are carefully kept as well as all computations of earth work and other quantities to be paid the contractor. The notes are kept in a bound field book and computations made on forms provided for the purpose.

Testing Materials.—The department maintains a highway laboratory for the purpose of testing materials used in the work. The laboratory through its own organization in co-ordination with the field forces, arranges for the sampling and testing of all materials of construction. In order to facilitate prompt testing of materials, the routine of carrying out this feature of the work is handled directly by the laboratory through the field organization.

The project engineer is not allowed to use materials in the work which have not been sampled, tested and found satisfactory. In case unsatisfactory materials are delivered to the work, the project engineer is required to furnish reports to the laboratory and construction office showing the disposition of the rejected materials. The routine of testing as it has been worked out precludes the possibility of unsatisfactory materials being placed in the work.

Inspection.—The inspection of the work in progress is one of the most important features of the field control of construction. The project engineer must be sufficiently experienced in construction work so that, under the direction of the resident engineer, he may see that the work is carried out in accordance with the spirit and intent of the specifications. On account of the multitude of his duties, it is not possible for him to be at all of the places on the job where work is in progress at all times. For this reason, it is necessary for him to have a sufficient number of inspectors under him to insure that all details of construction are carried out as contemplated.

In general, an inspector is assigned to each operation which requires for its success definite methods of procedure which cannot be varied and still obtain satisfactory results. These men must be conscientious and experienced in their work, and must be able to command the respect of the contractor's organization. It is advisable to utilize men for this purpose who have had experience in engineering work. The work of an inspector is excellent training for promotion through the organization.

Inspector's Records.—The inspector keeps accurate records of the conditions under which the work is done, records quantities of materials used and notes the workmanship employed in the construction. These records are reported daily to the project engineer, who arranges the information so collected in a manner such that it will give accurate knowledge of the job when completed. Wherever possible, materials represented by test reports are accurately allocated in the records to the points where they were used in the work. Accurate records are also kept of the weather, soil conditions and any other features which might affect the strength and usefulness of the completed work. This information is invaluable in the study of the completed project after it has been put into service.

The resident engineer, division engineer, and the central office are kept informed of the progress of the work by weekly reports submitted by the project engineer and by personal inspection of the field work.

Changes in Work.—The field organization is not permitted to change the plans or authorize extra work without first securing written approval from the central office, except in emergencies which cannot be anticipated. In this case, the division engineer is empowered to authorize the emergency extra or change. The recommendation, when it is received from the field, describes fully the change contemplated or extra work necessary. It is accompanied by such sketches as may be necessary to fully explain the work proposed, and necessity for it. The quantities of work involved and the unit prices to be paid for the work must also be noted.

Since the change in plans or extra work effects the contract, the recommendation must also be approved by the contractor. The recommendation is checked against the plans by the designer in the central office and when

approved by the chief engineer, it becomes an authorization to do the work. Since estimates for extra work or over runs of quantities can not be paid until they have been properly authorized, this method provides a constant check on operations in the field.

The careless interpretation of this requirement may cause delay of the work and therefore the central office insists, that all changes and extras, except emergencies be anticipated and authorized. This is absolutely essential in order that expenditures be kept within the budget. This system also constitutes a check on the accuracy of the original plans. A large number of changes in plans during construction should not be necessary if the original plans have been properly prepared.

The final record compiled by the field organization is a construction history, in which all of the information in regard to the construction of the project is completely described. It consists of instrument notes, earth work computations, culvert notes, inspector's diary and a summary of all of the items shown on the plans, compared with the items as finally constructed. This record also contains a narrative report which fully summarizes extra work and gives the reasons for over-run and under-run of quantities. The field computations of final quantities are checked in the office, and compared with the original plans and authorizations. When these quantities have been found correct the construction history constitutes the basis for payment of the final estimate to the contractor.

How the Construction History Is Used.—There is another use for the construction history which is fully as important as its use in determining final quantities.

In order to determine the action of the roads after they have been in actual service, we have for the past year been conducting a condition survey of roads which have been built in previous years. By comparing various types of construction under similar conditions of soil and traffic, we are able to secure accurate information to guide us in our work of design. We find we are hampered in our comparisons by a lack of accurate information of the conditions under which the roads were built, the methods followed and materials used in the work. This is especially true on the older projects. This information can be collected for a very small cost as the roads are being built and preserved for future reference.

This study of completed roads is in line with the work being conducted by a number of other states and it is the speaker's opinion that it is one of the most important features of our work today.

Super-Highway Plan in Wayne County, Mich.

Extract from Last Annual Report of County Road Commissioners

"In conjunction with the Rapid Transit Commission and the authorities of the adjoining counties, all the territory lying within a 10-mile radius from the Detroit City Hall has been mapped, and thereon has been laid a scheme of thoroughfares which have been designated as super-highways.

"The right-of-way widths have been selected, after much thought and detailed planning. Every 3 miles, a right-of-way having a total width of 204 ft. is being secured. The radial main arteries, which are of greater importance than meridan roads, since they have no main parallel highways, are also having the 204-ft. width. Between these super-highways there will be, at every 1-mile interval, a road built upon a right-of-way width of 120 ft. On the half-mile lines, the right-of-way will be 86 ft.

"In the area to which this plan has been applied, namely, that within a 15-mile radius from the City Hall, there will be 225 miles of these super-highways, of which 44 per cent, or about 100 miles, lies within Wayne County.

"We are carrying the plan further, however, on certain important thoroughfares. For example, on Michigan Road, which is Detroit's principla artery to the west, the super-highway will be carried to the western boundry of Wayne County, a distance of about 28 miles from the City of Detroit. On another artery, Woodward Avenue, which is our main thoroughfare to the northwest, there has been practically completed a highway which is consistent with our scheme of super-highways previously described. The State of Michigan and Oakland County has this improvement in charge, which will be continued to the city limits of Pontiac, a distance of approximately 16 miles from the Wayne County Line."

Changes in Wayne County Concrete Pavements

During the past season the Road Commissioners of Wayne County, Michigan, adopted, as a policy, shoulders of a minimum width of 10 ft., which in the case of a 20-ft. pavement, permits of parking outside the limits of the paved track.

The steel center-plate, placed longitudinally along the center of the concrete pavement has been universally adopted on all the county road construction.

Expansion joints are now placed at 100-ft. intervals and are 1 in. in thickness instead of ½ in. as heretofore.

Due to corner breaks, the Board has thickened the edges to 10 in.

Cost of Gravel Road Maintenance in Minnesota and Iowa

An interesting comparison of the cost of maintaining gravel roads is given in the June Service Bulletin of the Iowa State Highway Commission, from which we take the following:

"Graveled road maintenance expense in Minnesota in 1925 showed a 55 per cent increase over the figures for 1923. The average in 1923 on a Minnesota graveled road carrying 1,000 vehicles per day was $725.76. The average expense for maintenance on the same class of road in 1925 was $1,019.24. These figures are from a report issued by the Minnesota Highway Department.

"Iowa graveled road maintenance during this same period showed an average increase for the entire graveled portion of the system of $78 per mile. The average in 1923 was $441, the average in 1925 was $519.

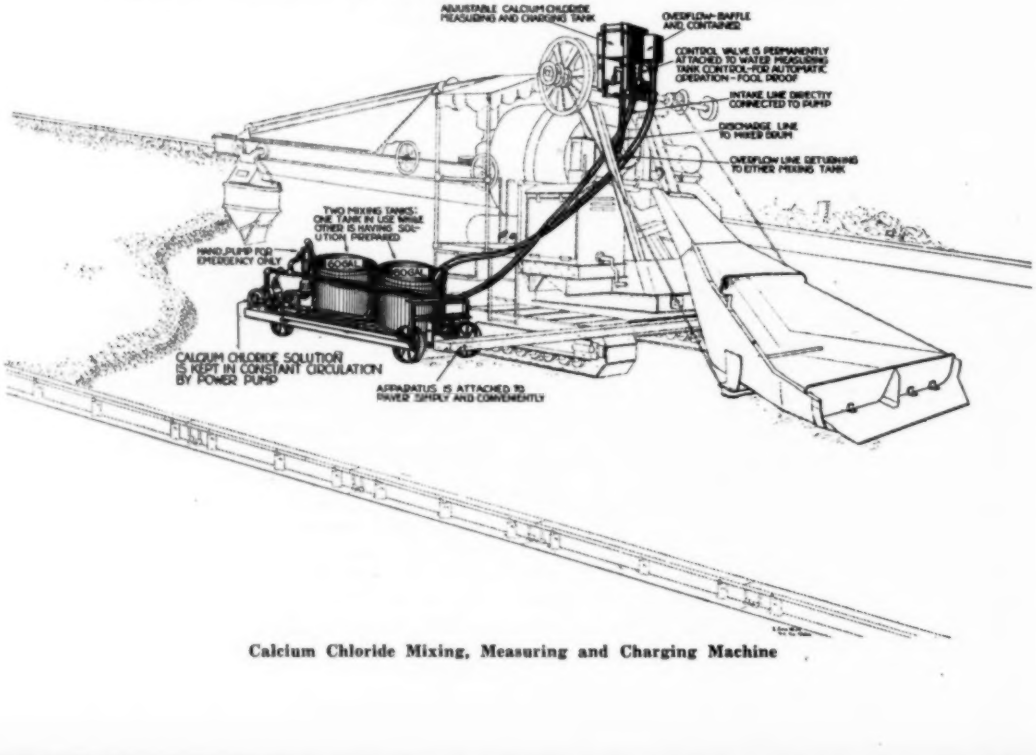
"Higher speed traffic, the lengthening of the tourist season, and more extensive all-winter use of main highways are suggested by the Minnesota Highway Department as the reasons for the 55 per cent increase in graveled road maintenance expense. The speed limit on the highways during the period was increased from 25 to 35 miles per hour. Snow removal, making it possible to increase the use of autos during the winter months, has also been responsible for a large portion of the increase. Comparison of the figures for maintenance depreciation between graveled and paved roads indicates to the Minnesota Highway Department that when traffic exceeds 500 cars per day it becomes economical to pave a main road. The increase in maintenance costs will make the economical limit on graveled roads considerably less than 500 cars per day and increase the mileage which the department believes could be profitably paved.

"Maintenance on paved roads in Minnesota averages between $150 and $300 per mile. The maintenance of the concrete slab itself has average approximately $50 per mile. The balance of the expenditure is for shoulder grade repairs and the erection of guard rail.

"Paved road maintenance in Iowa for the year 1925 averages $199. The maintenance on the slab itself is estimated to have averaged approximately the same as the Minnesota slab maintenance with the balance of the expenditures for shoulder work and other grade repairs."

New Calcium Chloride Machine

A new machine for the automatic regulation and injection of calcium chloride into a batch of concrete has been placed on the market by the Blaw-Knox Co., Pittsburgh, Pa. The machine may be applied to any mixer or paver. Only one additional man is required to prepare the solution and to handle the bags of calcium chloride. The machine is mounted on four wheels for easy transportation with the work, and is attached to the paving mixer, so as to move with the work.


ADJUSTABLE CALCIUM CHLORIDE MEASURING AND CHARGING TANK
OVERFLOW-BAFFLE AND CONTAINER
CONTROL VALVE IS PERMANENTLY ATTACHED TO WATER MEASURING TANK CONTROL—FOR AUTOMATIC OPERATION—FOOL PROOF
INTAKE LINE DIRECTLY CONNECTED TO PUMP
DISCHARGE LINE TO MIXER DRUM
OVERFLOW LINE RETURNING TO EITHER MIXING TANK
TWO MIXING TANKS: ONE TANK IN USE WHILE OTHER IS HAVING SOLUTION PREPARED
HAND PUMP FOR EMERGENCY ONLY
50 GAL.
50 GAL.
CALCIUM CHLORIDE SOLUTION IS KEPT IN CONSTANT CIRCULATION BY POWER PUMP
APPARATUS IS ATTACHED TO PAVER SIMPLY AND CONVENIENTLY

Calcium Chloride Mixing, Measuring and Charging Machine

Asphalt Pavement Research

Recent Developments Outlined in Highway Research News

By PREVOST HUBBARD
Chemical Engineer, The Asphalt Association

During the introduction and rapid adoption of asphalt pavements throughout the United States many years ago considerable study was given to the composition of asphalt paving mixtures with relation to their behavior under existing traffic conditions. Certain theories were evolved which could be sufficiently correlated with service results to produce satisfactory specification limits for the paving mixture itself and also of the individual constituents of the mixture. As a result of this study asphalt pavements soon come to be regarded as representative of the highest degree of scientific design and control.

With the marked changes in volume, weight and character of traffic which have occurred during the past 15 years certain modifications in the original design of paving mixtures have been adopted so that, in general, new construction has kept pace with the later traffic developments. In the minds of many careful thinking engineers, however, there has been developing a doubt of the logic, if any, back of certain of our customary and time-honored specification requirements, and for the past two or three years a number of investigators have been actively at work in an endeavor to broaden our knowledge of the laws which govern the behavior of asphalt paving mixtures under modern traffic.

Such general interest in the subject has developed that in January of the present year an Association of Asphalt Paving Technologists was formally organized for the specific purpose of investigating all phases of asphalt paving. This organization is expected to serve as a clearing house for all useful information developed upon the subject of asphalt paving. It has appointed a number of working committees, among the most important being one on research on paving compositions and one on control of street operations.

Given an adequate foundation, an asphalt paving mixture may fail when laid as a wearing course through improper design of the mixture itself or through faulty laying of the mixture. So far most of the research has been concentrated on composition of the mixture but the tremendous importance of certain construction details has been emphasized to such an extent by these studies that it is apparent that no real progress in the betterment of asphalt pavements can be made unless the two phases are developed simultaneously. Probably the most important problem today in connection with asphalt pavements is the prevention of shoving, rutting or other displacement under heavy motor traffic, through more logical control of composition coupled with closer attention to such details of construction as the obtaining of maximum practical compression, and original uniformity of contour.

Some five years ago the United States Bureau of Public Roads, in cooperation with a number of large eastern cities and The Asphalt Association, undertook an investigation of the cause and correction of shoving through a study of samples of existing pavements whose complete history could be ascertained. These samples of pavement were subjected to all of the customary methods of examination, but when the data was assembled it was found impossible to interpret results in the light of generally accepted theories governing such mixtures and it became apparent that a complete overhauling of the subject of design was needed.

In the first place it was quite reasonable to suppose that the older pavements which were at that time successfully carrying modern traffic had undergone certain changes since their original construction, so that their behavior would not necessarily be typical of the behavior of newly constructed pavements of the same original composition. The Bureau of Public Roads therefore undertook further to study the problem by means of short sections of asphalt pavements of varying composition constructed on a circular track at Arlington Farms, Virginia, and subjected to concentrated motor truck traffic. At the same time the Bureau and a number of independent investigators turned their thoughts to devising some method of measuring by means of a laboratory test the stability or resistance to displacement of small samples of compressed asphalt paving mixtures.

Considerable progress has been made in the development of such a laboratory test and it is believed that the information being developed by these tests will shortly clear up the apparent contradictions encountered in the earlier investigations and will quite probably result in an entire revision of theories governing design. During the 1925 Annual Meeting of the American Society for Testing Materials a number of important papers upon this subject were presented and discussed. Further interesting developments were presented at th Fourth Annual Asphalt Paving Conference in Detroit during the latter part of 1925 and so much interest in the subject was displayed

that an entire session of the Fifth Asphalt Paving Conference to be held in Washington, D. C., during the week of Nov. 8, 1926, will be devoted to asphalt pavement research.

Any investigation of asphalt paving mixtures is complicated by the large number of factors having a direct influence upon stability, such as size and grading of the mineral aggregate, percentage, type and quantity of mineral filler, quantity and consistency of asphalt cement, degree of compaction of the mineral aggregate, and maximum temperature of the mixture in service.

These factors are gradually being analyzed with reference to their importance and interrelationship. From the work already accomplished it seems safe to predict that in the near future a newer and more logical theory of design will be evolved which if put into practice will insure even more satisfactory service results than have been obtained in the past.

Wisconsin Regulations for Road Signs

On May 15 the following regulations of the Wisconsin Highway Commission on the erection of signs on public highways went into effect:

1. No sign shall be erected on any public highway except such as are necessary for the guidance or warning of travel. No sign having the words "Stop," "Beware," or other words commonly used to warn travelers on the highway of hazards connected with such travel, or words used on highway signs erected by public officers, shall be erected except by the public officers having jurisdiction over the highway on which such sign shall be erected.

2. Any person or persons conducting a summer or winter resort, hotel, or any place of public entertainment or instruction, or any place of religious worship, which shall be located removed from any public highway, may erect not more than three signs to guide travelers to such summer or winter resort, hotel, place of public entertainment or instruction, or place of religious worship.

3. Any department of the state may erect such signs as shall reasonably be deemed necessary to warn the traveling public against violations of state laws or lawful regulations by any such state department.

4. Persons having charge of any county institution or of any scientific experiment for the furtherance of agriculture or other science or art being conducted on grounds removed from any public highway, may erect not more than three signs to guide travelers to such county institutions, or scientific experiment for the furtherance of agriculture, science, or art.

5. No sign with an area greater than 25 square feet shall be erected on any public highway. All signs shall be erected as close to the outer limit of the highway as is practicable, and all signs having any dimension greater than two feet shall be set parallel to the direction of the highway. If any such sign is erected where the highway is on a curve, the sign shall be erected on the outer side of the curve.

6. One of the three signs permitted to be erected by any summer or winter resort, hotel, place of public entertainment or instruction, place of religious worship, county institution, or any scientific experiment for the furtherance of agriculture or other science or art shall be erected at the place where travel leaves the highway to pass to such summer or winter resort, hotel, place of public entertainment or instruction, place of religious worship, county institution, or scientific experiment for the furtherance of agriculture or other science or art. And such summer or winter resort, hotel, place of public entertainment, or scientific experiment for the furtherance of agriculture or other science or art may erect not more than one other sign within the limits of the highway, not more than one-fourth mile in each direction from the first sign mentioned.

7. No signs within the limits of any public highway except the signs erected by or under the supervision of state departments shall use any combination of black letters or figures on a white or yellow background.

8. All signs erected within the limits of a state trunk highway shall be so located as to meet the approval of the State Highway Engineer or his authorized representative, and the signs erected on other highways shall be so erected as to meet the approval of the public officers in charge of the maintenance of such highways.

Iowa Issues Pipe Culvert Bulletin.—"A Preliminary Experiment on the Supporting strength of Culvert Pipes in an Actual Embankment" is the title of Bulletin 76, just issued by the Engineering Experiment Station of Iowa State College. This gives the results of a highway research investigation conducted at Ames in cooperation with the U. S. Bureau of Public Roads. The experiment described is the first of a number planned to determine for different kinds of culvert pipe, embankment materials and field conditions, the ratios between the supporting strengths which culvert pipe can be counted upon to develop in actual use and the laboratory strengths of such pipes when tested by standard methods.

What Winter Does to Roads

Effects of Alternate Thawing and Freezing and Methods of Combating These Conditions Described in the Highway Magazine

By N. M. ISABELLA

Maintenance Engineer, Wisconsin State Highway Commission

What winter does to roads can be very easily observed in the spring of the year after the snow and frost leave the ground. Dirt roads and roads surfaced with material such as gravel, shale, and other light surfacings, are apt to lose their identity through action of the winter elements.

Fig. 1—Bad condition of gravel road due to alternate thawing and freezing.

Many ideas and suggestions are offered by various highway engineers and officials to combat the action of the winter elements. Many ideas and methods have been used, some of which have proved satisfactory, and many of which have been of little value.

The Average Gravel Road.—Let us consider the average gravel road as it goes into winter. There are many things that occur in the fall of the year that will affect the condition that it will be in in the spring. In an unusually wet fall season there is bound to be a great deal of seepage of water and moisture into the roadbed, especially so where the drainage away from the road is rather inadequate. This moisture freezes when cold weather sets in, and while it is in the frozen state, very little can happen to the road. However, usually there are warm spells during the winter, causing the surface of the road, at least, to thaw out. In many cases this causes disintegration. A road will fare much better if winter thaws are not experienced, as the continual changing occurring on the surface of the road from freezing and thawing is very detrimental.

This is very plainly exemplified in Fig. 1 of a surface treated gravel road. These rough conditions were caused by the melting of snow and subsequent thawing of the surface, and with continual traffic over the surface of the road, disintegration took place. This road went into the winter in very fine shape, and shows very clearly what may happen due to a warm spell during the winter months.

Ruts Along Side of Concrete Roads.—Many of our concrete roads have cracked, due to the seepage of moisture under the slab and subsequent frost action. In many cases, the moisture seeps into the roadbed along the edge of the pavement where ruts are allowed to form in the fall of the year, when farmers are

Fig. 2.—Section of Wisconsin highway that had a few chuck holes in the late fall that were not patched before cold weather began, necessitating, in the spring, large patches shown here.

doing a considerable amount of hauling. Usually the team traffic is responsible for a good share of the ruts along the concrete roads. In order to give plenty of clearance to the fast moving traffic, some of the horse drawn vehicles run one wheel on the soft shoulder and the other on the concrete slab. The wheel on the soft shoulder, of course, forms a rut and a place for the fall rains to soak into the roadbed. These can be properly filled by the

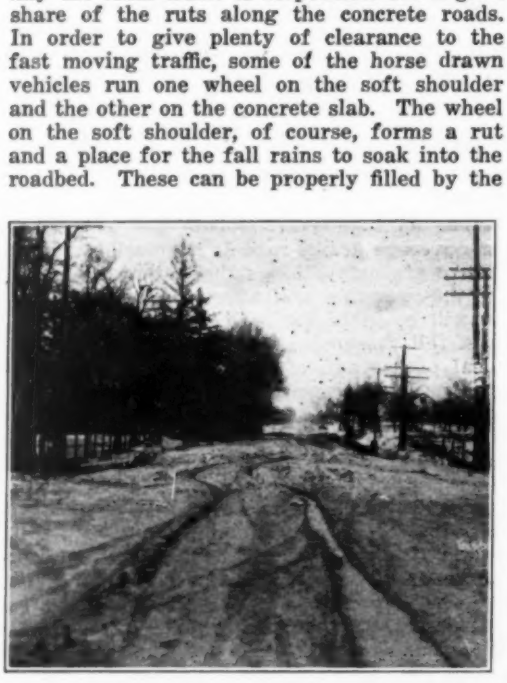


Fig. 3—Section of Wisconsin highway showing wheel tracks formed by one-way traffic on surface treated gravel road.

patrolmen in their regular maintenance operations, but quite often the damage is done before they get to this part of their work.

Permitting the forming of chuck holes and low spots in either macadam, gravel, or surface treated roads, is also responsible for disintegration of the surface. Fig. 2 shows a road that had a few chuck holes in the late fall, which were not patched before cold weather set in. As a result, disintegration took place and made necessary the large patches shown in this picture. A road in this patched condition will permit traffic to move over it without any great inconvenience, but is not as good as the original road.

The effect of snow removal on the surface of various types of road has been a question very much discussed by engineers throughout the country. There is no question but what the removal of snow from the surface of the roadway has its effect on the subsequent action of the elements. In many instances, the snow is cleared from the travelled way wide enough to permit only one way traffic. This concentrates the wear on a certain strip of the road surface. Fig. 3 shows quite clearly the wheel track formed by the one-way traffic on a surface treated gravel road.

When the Frost Leaves the Ground.—A very critical period each year in the life of a road is that period when the frost is leaving the ground. If a road could be closed to traffic at this time, many of the failures that come in the spring of the year could be eliminated to a great extent; but the continual pounding of traffic over the shell or crust of the road causes the failures such as shown in Fig. 4. This was a very good gravel road only six months before. The hot spring sun pouring on the surface of the road tends to draw out the frost, particularly at the weak places. The action of traffic over the surface, together with the warm sun, facilitates the breaking up of the crust at these places. Many times these weak spots occur where moisture has accumulated in the roadbed due to either poor drainage or to subsoil conditions.

Preparing Roads for the Winter.—Extreme variations of temperature are more prevalent, of course, in the northern sections, and no doubt road failures predominate in these localities. What may be suggested as a cure in the northern sections may not be the exact cure for road failures in the more southern localities. However, it is believed that most highway engineers are of the opinion that a

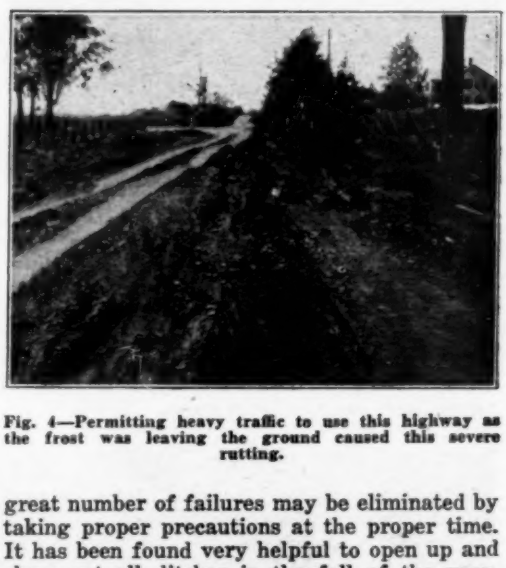


Fig. 4—Permitting heavy traffic to use this highway as the frost was leaving the ground caused this severe rutting.

great number of failures may be eliminated by taking proper precautions at the proper time. It has been found very helpful to open up and clean out all ditches in the fall of the year, and provide outlet ditches to get the drainage away from the road. The cleaning out of all culverts is also very essential. The sealing of cracks in concrete roads with bitumen will prevent the seepage of water through these cracks in the fall season. Repairing of shoulders and filling in of ruts along the edge of the slab with either gravel or crushed stone will materially reduce the seepage due to this condition.

In Wisconsin it has been found good practice to give the dirt and light surfaced roads slightly more crown in the fall than they usually have during the summer season. This helps the surface drainage considerably and permits moisture and water to drain to the side ditches rapidly, thus preventing the moisture from soaking into the roadbed. It is very essential that the surface of the road be smoothed before it goes into the winter. All chuck holes and low places should be repaired, and in the case of surface treated roads, all holes should be patched and sealed. A study should be made of the road in question and wherever it is known that a road is apt to break up in the spring, material should be stock-piled along the side to be used when necessary. Each patrolman knows his section quite well and has a fairly good idea of the particular places that may give trouble, and

Fig. 5—Section of Wisconsin highway which showed no ill effects from winter forces due to thorough cleaning of ditches and drainage structures in fall.

by giving these places special care in the fall and making preparations for the spring, many of the road failures that have occurred in the past can be eliminated in the future.

Treatment of Frost Boils.—On quite a number of the roads in Wisconsin it has been found that breakups occur in practically the same location every spring. Some of the commissioners have facilitated break-ups or "frost boils," as they are often called, with the use of dynamite. In this way, they open up the section of the road that is bad, and allow the moisture to drain out as the frost comes out. In quite a number of cases it has been necessary to plank the road and permit only one way traffic on short sections.

Another method that has proved quite satisfactory in the treatment of "frost boils" is as follows: Take the section of road where the break-up is apt to occur, close half of the roadway, and dig a trench across the road down to at least the depth of the side ditches. This will permit the frost to drain out to the side and will not disturb the surface. After this has drained for a few days, the trench may be filled in with stones and gravel and then covered with the regular surfacing material.

The foregoing are a few of the ideas and experiences that have been observed in Wisconsin, and no doubt are similar to those in states of this latitude. The remedies suggested are some that are known to have worked out successfully, and may help solve the problem in some other locality. Through the constant exchange of ideas the solving of highway problems will become less difficult each year.

U. S. Bureau of Public Roads Making Sub-Grade Field Studies

Field studies of subgrade soils by the U. S. Bureau of Public Roads with State coperation are in progress in Georgia and Virginia, according to Highway Research News. An attempt is being made to correlate the condition of the pavements on various subgrade soils with the kind and condition of the soil. The ultimate objective, of course, will be to determine the characteristics of good, bad or doubtful subgrade soils, so that they may be readily identified in the future. This should be helpful in selecting adequate pavement designs.

In Georgia eleven Federal-aid projects from 2 to 4 years old, and totaling 75 miles, have been selected for study. The projects were built on various soil types and include topsoil, bituminous, and concrete surfacing.

In Virginia the work is confined to one project located between Fairfax Courthouse and Warrenton. It includes both plain concrete and vibrolithic concrete construction.

The field work in the Georgia investigation is expected to include the mapping of the pavement and ground surface conditions in detail, observations of drainage and topography, and the selection of soil samples for laboratory analysis.

In the Virginia study a survey of the subgrade was made before construction began. While the pavement is being built at the present time, detailed information is being secured on weather conditions, final preparation of the subgrade, character and condition of the materials, method of mixing, and the consistency, finishing and curing of the pavement. A condition survey of the pavement is being made prior to the placement of the wet earth covering. This condition survey will be supplemented later at intervals beginning when the road is opened to traffic.

Results of Road Impact Tests

Some deductions drawn from data obtained by the Bureau of Public Roads in a series of tests of motor truck tire impacts on road surfaces, extending over the last two years and carried out in co-operation with the Society of Automotive Engineers and the Rubber Association of America, were given in an address by J. A. Buchanan, of the Bureau, and J. W. Reid, of the Association, at the summer meeting of the Society during the first week in June.

These conclusions are that the impact reactions, or force of the blow, increases as the weight supported by the tire is increased but that the ratio of the reaction to the weight becomes less as the weight is increased; that the narrower the tread rubber of solid tires is, the less is the impact reaction and that increasing the height of the tread rubber has a marked effect in reducing the impact reaction in both single and dual tire mounting; that dual tires cause greater impact forces than single tires of corresponding load capacity; that breaks in continuity of the tread surface cause heavy repeated road impacts, and that dual tires should be mounted with the tread design staggered.

In the tests the vertical reactions from road obstructions were measured by a specially constructed instrument called an accelerometer mounted on the truck and designed to measure the force and speed of upward thrusts and at the same time to measure the proportional deflection of truck spring adjacent to wheel.

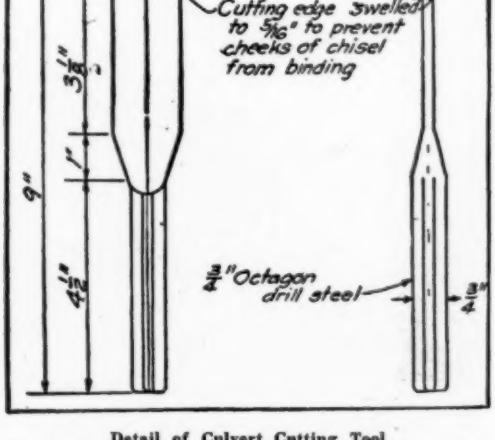
The results show that pneumatic tires may make a rough road seem reasonably smooth and solid tires in poor condition may make a smooth road seem unreasonably rough. A few tests indicated that no great difference in effect was produced by varying the unsprung weight, that is, the weight of wheel, tire and axle below the vehicle spring supporting the frame and its load.

From a cushioning viewpoint, the combination of a low pressure balloon tire or an underinflated high pressure pneumatic tire, a relatively high unsprung weight, and a comparatively flexible truck spring, might eliminate all but the severest road roughnesses.

A change in mounting dual tires having a very deep non-skid design, so that the depressions in the two tire treads were staggered instead of being opposite each other, resulted in reducing the impact reaction from 3,600 lb. to 1,200 lb. at each repetition of the tread design on a smooth concrete road. The greatest impact reactions occurred with all the trucks at speeds between 12 and 15 miles an hour. The impact force with pneumatic tires had a duration of 8/1000 of a second, and with a wornout solid tire of about 2/100 of a second.

Tool for Cutting Corrugated Culverts

A simple tool for cutting corrugated culverts is described in a recent issue of The Highway Magazine. As the sketch shows, it is simply a chisel-shaped hand tool that can be made, if desired, from an old cold chisel or a piece of hardened steel. The cutting operation is started by driving the sharp corner into the metal. As the tool is driven around the circumference, a quarter-inch strip of metal is cut away by the two cutting edges. This strip is neatly cut out of the pipe, whereas a cold chisel or sharp-edged tool wedge and split the pipe.



Detail of Culvert Cutting Tool
It is important that the tool be made of hard steel, as the concave cutting edges will otherwise become dulled quickly.

Culvert extensions are commonly made by severing the pipe with this tool just back of the headwall, and moving the headwall bodily into the excavated new location. The new sections of pipe are then rolled into the gap and hand riveted, after which backfilling completes the job.

Although culverts are usually ordered with special ends to fit skewed headwalls, changes of plans often make it necessary to cut the pipe to a skew on the site. The culvert cutting tool comes in handy for this operation, as well as for making other changes in the pipe.

The 1926 Wisconsin Road School.—The 15th Annual Road School of the Wisconsin Highway Commission had a registered attendance of 1,019. The largest previous attendance was 963.

Street Lighting

Recent Developments Outlined in Committee Report Presented June 10 at Annual Convention of Pacific Coast Electrical Association

The amount per capita per year a city or town will have to pay for properly lighting all of its streets depends somewhat on its size, density of population, traffic conditions and layout of streets. However, the following table shows the average yearly per capita expenditure based on the experience of well lighted cities throughout the United States:

Population	Per Capita per Year
Less than 5,000	$2.50
5,000 to 20,000	2.00
20,000 to 100,00	1.75
Over 100,000	1.50

Street Lighting Plan.—These figures are approximate and intended only as a guide. The actual amount any city should spend must be determined by first formulating a plan. The first step is to secure a large map of the entire city and lay out the streets in accordance with the following subdivisions:

I—Principal Business Streets
II—Secondary Business Streets
III—Main Traffic Arteries
IV—Secondary Traffic Arteries
V—Residential Streets and Park Drives
VI—Alleys
VII—Manufacturing and Wholesale Districts
VIII—Highways and Undeveloped Districts

The above applies, of course, to a large city. However in laying out a plan for a smaller community the method is the same except certain classifications will not be used and the problem is therefore simplified in proportion to the size of the city. Where a city plan is available it should be used as the basis for the street lighting plan. If not available the street lighting map necessarily becomes the city plan. It is important to have the advice of city planning experts in connection with this work.

Recommendation for Ornamental and Overhead Lighting.—After the streets have been classified the next step is to specify the quantity of light for each classification. Lumens per linear foot of street have been generally accepted as the proper basis on which to classify the different degrees of street illumination. Table I gives general recommendations for ornamental street lighting and shows both the minimum and the most desirable lumens per foot recommended. It should be kept in mind that these classifications and recommendations are for cities of 100,000 population or larger and in the small city the main business street would be classed as secondary business in the larger city. Likewise the smaller city main thoroughfares should be considered as secondary. Residential streets if important enough to have ornamental lighting would be the same whether in a small or large city.

Table I—General Recommendations for Ornamental Street Lighting

Class of Street	Available Lamps	Mounting Height feet	Feet of Street per standard	Lumens per foot of street
Intensive White Way Arc Lamps	6.6 ampere luminous 15,000 and 25,000-lumen Mazda lamps	18-25	50- 75	300-500
White Ways	6.6 amp. luminous arc lamps			
Principal business streets	10,000 and 15,000-lumen Mazda lamps	14-16	40- 65	200-400
White Ways	6.6 amp luminous arc lamps			
Secondary bus. streets	6,000, 10,000 and 15,000-lumen Mazda lamps	14-16	40- 65	125-250
Main Thoroughfares	4,000, 6,000 and 10,000 Mazda lamps	14-16	50- 75	80-150
Secondary Thoroughfares	2,500, 4,000 and 6,000-lumen Mazda lamps	12-14	50- 75	50-80
Residential streets, Boulevards and Park Drives	2,500 and 4,000-lumen Mazda lamps	11-14	60-100	25-50

Outside of the business district, however, practically all lighting will be overhead. Table II of recommendations will serve as a guide.

It will be noted that slightly lower minimum lumens per foot of street are allowed for overhead lighting as compared to ornamental standards. This is possible because the pendant fixture which reflector or refractor delivers more of the available light rown upon the street surface. In specifying the lumens per foot for any class of street it is important to use large lamps at the minimum spacing. By using large lamps a given amount of light can be secured for less money because large lamps are more efficient in lumens output per watt and a smaller number of large units means less maintenance than a large number of small units. In this connection it is recommended that no lamp be used smaller than 2,500 lumen, until every street intersection is provided with at least a 2,500-lumen lamp. The 1,000-lumen lamp may be used in the middle of the block in secondary residential sections where a light is needed and funds are not available for a 2,500-lumen lamp.

Table II—Recommendations for Overhead Street Lighting

Class of Street	Size Lamp	Mounting Height Feet	Feet of Street per Lamp	Lumens per foot of Street
Main Thoroughfares	6,000 and 10,000-lumen Mazda lamps	15-25	75-150	80-150
Secondary Thoroughfares	2,500, 4,000 and 6,000-lumen Mazda lamps	15-25	75-150	35-80
Main Residential, Apartments and Wholesale District	2,500 and 4,000-lumen Mazda lamps	15-25	75-300	25-80
Secondary Residential	1,000 and 2,500-lumen Mazda lamps	15-20	100-200	10-25
Highways, Alleys and undeveloped sections	2,500-lumen Mazda with Highway unit	30-35	300-400	6-8

Selection of Equipment.—After determining the quantity of light the next step in formulating the plan is to select fixtures that will best meet the requirements. In the selection of lighting equipment perhaps the main items to consider are costs, appearance, illumination and depreciation. Table III shows in more detail what goes to make up these items and suggests weighing factors that might be used if an accurate comparison of serveral system is to be compiled for a main traffice artery.

Table III—Basis for Comparison of Ornamental Street Lighting Systems for Traffic Arteries in Per Cent

Costs	30	Installation	15
		Operation and maintenance	15
Appearance	30	Daylight—standard and fixture	10
		Night—of fixture	10
		General—of entire street at night	10
Illumination	30	Ability to see	20
		On street	8
		At street intersection	3
		On intersecting street	3
		On sidewalk	2
		House numbers	2
		Between houses	2
		Absence of glare	10
		From street	6
		From sidewalk	2
		From house	2
Depreciation	10	Ability to stay clean	5
		Ability to stay in adjustment	5

Figures indicate percentage allotment or weighing factor for each fixture. Each item should be rated on a scale of 100 with regard to each characteristic. A final rating will then be derived by multiplying the rating of each characteristic by its weighing factor given in the above table and dividing by 100.

Some changes in weighing factors would be necessary for other classes of streets. Usually, however, an accurate comparison is not necessary if the selection is to be made by one with some experience in judging lighting systems.

Table III may be regarded as advice in the selection of equipment. Judgment should not be passed on only a few samples as it is the cumulative effect of a long line of lights that really counts. Installations of modern illuminants usually are available in nearby cities and it is far less expensive and more satisfactory to visit such installations for comparison than to attempt to duplicate them on a small scale in your own city.

One of the main advantages of a street lighting plan is the opportunity at affords for selecting standards and fixtures varying in size and output, but similar in design. Thus when the plan has been fully carried out the street lighting equipment is uniform in design, giving the streets a neat, orderly appearance. All of the best designs of ornamental fixtures and standards are now available in several sizes making up what is known as an "Architectural Family" of standards.

Recent Developments.—Practically all new installations are using the rippled or rectilinear type of glassware which has practically superseded the old style opal glass. This new glassware with its surface broken up into tniy hills and valleys has several important advantages over the smooth surface opal glass. Briefly these are as follows:

1. Less absorption of light. Light is diffused by uneven surface of glass rather than by opaque opal substance.
2. Sparkling appearance more pleasing both by day and by night.
3. Permits the use of refractors giving various types of light distribution.
4. Easy cleaning. Rain does not streak globe but dirt settles in ridges and is carried away.

In addition to the improved glassware several new types of refractors have been developed. These are of asymmetric type and are designed to re-direct light from the sidewalk and the upward hemisphere, into an agle below the horizontal on the street side. Asymmetric distribution is ideal for residential streets if used properly so as to eliminate sharp contrast and glare.

For pendant lighting the totally-enclosing, bowl-type refractor has practically superseded the open band type, because it is dust and bug-tight. Also dust collection on the bowl does not reduce the light output to such a degree as with the band, and cleaning easier.

Another advance that has been made in overhead lighting practice is the use of rigid-bracket or mast-arm mounting in place of center-suspension units. When only very small lamps were available it was necessary to hang the fixture directly over the street intersection to secure any effective light. With the high intensity light sources used today better visibility is secured on the street when the lamp is mounted high or near the curb where it is out of the direct line of vision of the automobile driver. Rigid brackets or mast arms are recommended in place of center suspension for the following reasons:

1. Better visibility. Even when the unit is screened by tree foliage the light filters through and the freedom from glare is an advantage.
2. Better appearance of the fixture and of the entire street.
3. Ease of maintenance, because fixture does not swing in the wind.

Road Widening in Michigan.—The state highway department of Michigan has secured additional right of way on about 400 miles of road. The right of way now ranges from 86 ft. to 200 ft.

Oiling for Preventing Sand Drifts

Method of Protecting Road Slope and Shoulder in Imperial County, California, Described in California Highways

By C. L. McKESSON
Materials and Research Engineer, California Highway Commission

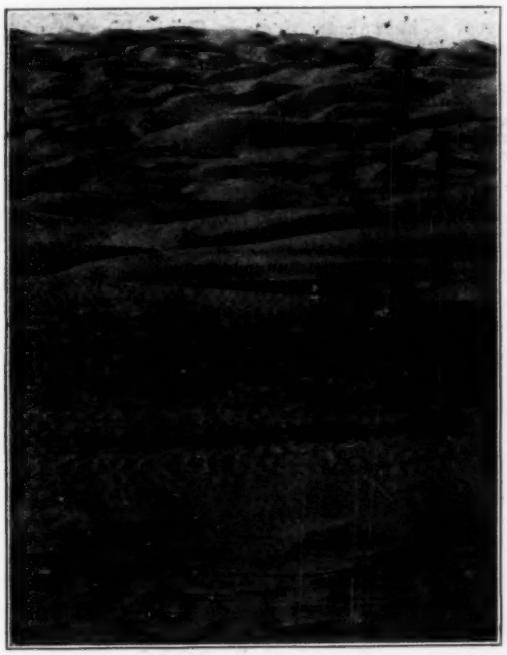
The sand hills section in Imperial County, in California, is one on which highway engineers have battle the wind ever since highway construction began in that section. Since the construction of the temporary plank road across these dunes, each heavy wind storm has buried long stretches of the highway beneath deep sand drifts in some ways not unlike the snow drifts of other regions. Thousands of dollars have been expended in removing the sand only to have it replaced by the next storm.

The Oregon highway department has waged a similar battle with drifting sands along the Columbia River east of The Dalles, and in a single wind storm has lost long stretches of newly graded highway. Before the advent of the Columbia River highway the railroad had been for years engaged in a struggle against the drifting sands, and perhaps it is to its engineers that we are indebted for the initiation of the practice of oiling as a protection against wind action. The Oregon Highway Department after a few rather disastrous experiences adopted oil protection, to the extent of oiling large areas on the windward side of the highways as well as the highway right of way and the slopes.

Protection Planned for Sand Hills.—In planning the new highway across the sand hills section, engineers of the California Highway Commission responsible for design and construction decided to utilize oil for slope and shoulder protection, and the Testing and Research department was asked to make tests to determine character of oil suitable for the work and the amount required.

Rather simple tests were made which, it is believed, indicate service values. These tests will be described for the benefit of those interested in the problem of drifting sands or wind erosion.

In making the tests various oils were used with asphalt contents up to about 65 per cent. The experiments have demonstrated that the oil best suited for the work should contain 40 to 50 per cent of asphalt. Oil of this kind can be applied without heating and will penetrate



View of section of 6 miles of Dunes in Imperial County across which a pavement is now being built. Shoulders and slopes will be oiled to prevent erosion by winds.

Table I—Results of Test or Penetration of Desert Sand With Various Asphaltic Oils

Kind of Oil	Sp. Gr. Be	Amt. Per Sq. Yd. Gal.	Penetration Cold Sand	Penetration 150° 1 Wk.	Remarks
43% Asphalt	18.2°	½	¼	⅝	Applied at about 75° F.
		¾	½	1¼	
		1	⅞	1½	
Fuel Oil	17.2°	½	½	⅝	Applied at about 75° F.
		¾	⅝	⅞	
		1	¾	1⅛	
50% Asphalt Road Oil	16.8°	½	¼	½	Applied at about 75° F.
		¾	⅜	1¼	
		1	1¼	1¾	
62% Asphalt Road Oil	15.2°	½	¼	⅜	Applied 150°-175° F.
		¾	½	¾	
		1	¾	1¼	
65% Asphalt Road Oil	13.7°	½	½	¾	Applied 150°-175° F.
		¾	¾	1	
		1	1	1¾	

readily. There is a sufficient asphalt content to give good body and to hold sand particles together in a heavy flexible mat after the more volatile oils have evaporated.

Oil Tests.—A large sample of the desert sand for test purposes was obtained from Division Engineer E. Q. Sullivan. The sand was placed in pans having an area of 1 sq. ft. and the oil applied in a finely divided spray under an air pressure of 50 lb. Repeated trials indicated that ½ gal. per square yard was the least amount that would entirely cover the sand. The lighter oils were applied cold and the heavier oils were heated. After the application of oil, the resulting oil cake was cut in small squares and the average thickness measured. The values given in Table I are averages of a number of samples.

After measuring the penetration of oil in the cold sand the pans containing the sand were placed in an oven and maintained at a temperature of 150 deg. F. for one week and the depth of penetration again determined. This was done to determine maximum probable penetration which will be obtained in the summer time under desert heat conditions.

A Diesel oil was also tested but it lacked "body" and did not produce a good oil mat on the sand.

All of the oils gave good mats of oil and sand but the lighter oils gave good penetration without heating and were therefore recommended for use.

Oiling as above described gives protection against drifting sand when adjacent dunes and sandy areas are oiled and is also useful in preventing erosion of sand fills by wind and water.

Surfaced Roads in State Systems Totaled 145,508 Miles January 1, 1926

Nearly 18,000 miles of road in the several state highway systems was surfaced in 1925, according to reports received by the Bureau of Public Roads of the United States Department of Agriculture from the state highway departments. In addition, 5,316 miles of earth road was graded and drained according to engineering standards, making a total of 23,152 miles improved during the year, of which a little more than 10,000 miles was constructed with federal aid.

At the end of the year the total surfaced mileage in the state systems had reached 145,508 miles, and there were 32,218 miles of earth road, graded and drained according to engineering standards. The total of 270,654 miles included in the state systems embraces the important roads of the country which have been laid out to serve the needs of the states. It is upon these systems that the important through routes of the federal-aid system and the United States highways have been almost entirely laid down.

The surfaced roads in the state systems at the close of 1925 were of the following types: Sand-clay 12,677 miles, gravel 64,408 miles, waterbound macadam 4,804 miles, surface-treated macadam and gravel 15,858 miles, bituminous macadam 10,985 miles, sheet asphalt 839 miles, bituminous concrete 4,821 miles, cement concrete 27,875 miles, brick 3,111 miles and miscellaneous 131 miles.

The following table indicates the progress made by the various states:

	Mileage in State system	Surfaced mileage existing at end of 1925	Surfaced mileage completed during 1925
Alabama	3,953.5	1,833.0	266.9
Arizona	2,044.4	1,452.5	84.3
Arkansas	8,295.0	3,795.0	586.0
California	6,591.4	3,383.3	256.9
Colorado	8,392.8	3,456.8	125.1
Connecticut	1,871.9	1,725.0	111.5
Delaware	505.7	505.7	73.1
Florida	4,490.0	2,194.7	218.4
Georgia	6,231.7	2,472.5	231.5
Idaho	4,627.3	2,196.4	204.0
Illinois	4,819.5	4,168.2	732.9
Indiana	3,935.6	3,860.0	306.2
Iowa	6,674.1	3,029.4	347.8
Kansas	7,386.0	962.8	129.0
Kentucky	8,000.0	2,272.3	206.6
Louisiana	7,000.0	3,821.7	424.1
Maine	1,459.4	1,218.7	46.2
Maryland	2,429.0	2,429.0	185.1
Massachusetts	1,541.8	1,529.1	88.0
Michigan	6,706.6	6,025.8	436.7
Minnesota	6,954.5	5,978.6	550.2
Mississippi	5,500.9	2,689.7	63.7
Missouri	7,640.0	2,601.4	1,260.4
Montana	7,957.0	859.4	139.2
Nebraska	5,619.0	1,881.4	966.7
Nevada	2,996.7	873.6	206.2
New Hampshire	2,081.2	1,767.9	140.2
New Jersey	1,290.0	1,181.9	84.1
New Mexico	9,159.0	1,615.5	138.2
New York	13,900.0	9,625.9	589.3
North Carolina	6,432.2	5,311.5	976.6
North Dakota	6,174.0	803.5	262.4
Ohio	10,784.0	9,501.6	1,286.3
Oklahoma	5,589.0	1,348.4	267.3
Oregon	4,446.3	3,008.4	204.4
Pennsylvania	10,827.8	7,655.5	1,012.7
Rhode Island	768.4	405.8	37.6
South Carolina	4,951.0	3,220.8	242.0
South Dakota	5,918.0	2,023.0	551.4
Tennessee	4,644.4	2,599.4	291.4
Texas	16,668.0	7,954.0	1,027.7
Utah	3,132.3	1,058.0	120.7
Vermont	4,466.0	3,067.4	199.0
Virginia	4,920.4	3,559.9	172.5
Washington	3,266.0	2,542.0	287.3
West Virginia	3,664.0	1,262.7	284.7
Wisconsin	10,264.5	7,978.0	1,315.7
Wyoming	3,143.3	801.8	97.8
Totals	270,653.6	145,508.9	17,836.0

*Covers only 6 months of year.

Improvement in Smoothness of Concrete Road Surfaces.—Measurements of road roughness made recently in one of the Federal Aid districts with an instrument designed and built by the U. S. Bureau of Public Roads, showed that since 1920 there had been an improvement in the smoothness of the surface of the concrete pavements laid. Pavements laid during 1925 showed only about one-half the surface roughness of those laid 5 years ago.

Sand-Clay Construction

Experimental Road Built in Washtenaw County, Michigan, Described in Addresses Presented Feb. 17 at Highway Engineering Conference, U. of M.

By A. R. BAILEY
Engineer-Manager, Washtenaw County Road Commission

A little over a year ago Professor Blanchard conceived the idea of using one of the Detroit Edison Fellowships in investigating sand-clay road construction as applied to this latitude. We all know that sand-clay roads are a success in the southern states where there is no frost action, however, we do not now whether they can be made a success in Michigan. Professor Blanchard arranged for a Detroit Edison fellow, C. S. Jarvis, to make a study of this subject with the idea of our carrying out the field work of construction during the year 1925.

Location of Road. — In deciding where we would do the experimental work with sand-clay we took into consideration the source of supply of sand as well as the soil conditions of the road to be constructed and for these reasons a section of the North Territorial road was chosen. This section connects M-65 and the Pontiac Road and is about 5 miles in length. Before any construction work was started, Mr. Jarvis went over the road using an auger and took test borings, numbered the samples and then took them to the laboratory where the tests were completed and recommendations were afterward made as to the amount of sand necessary to be added to the natural soil to give the desired results.

Construction Methods.—A grading contract was let during April and May 5th the contractor started grading work at the M-65 end of the road and worked east. As soon as the first mile and a half of grade was ready for sand which was early in June, we channeled the grade as is customary in building a gravel road except the depth was much less. The sand was then spread from the trucks the same as gravel is handled and immediately the clay that had been thrown out from the channel was thrown back over the sand and a team with a spring tooth drag was used for mixing the sand and clay. There was very little traffic over the road on account of the easterly portion of the road being under construction during the summer so there was not much traffic for compacting the materials. This mile and a half has been under traffic since the middle of June except for one month during the time a bridge was being constructed in the middle of the section. We found the sand compacted with the clay quite readily even under the light traffic and the road had all the appearances of an ordinary gravel road. In the fall there was an unusual amount of rainfall; however, it had no effect on this section of sand-clay except to cause ruts to form during each rain. As soon as the rain had stopped and a grader or spring scraper floated the surface, the road was again smooth and continued this way until the next rain.

Grading work progressed very slowly on the remainder of the road so that no further surfacing was done with sand until early in September. The sections, approximately a mile in length, were surfaced as rapidly as completed, the same method being used as described above on the first section of a mile and a half. We did not learn until late in November that owing to the extremely wet season we had made a serious mistake in channeling the subgrade before applying the sand; this does not apply to the work done in June. As you may suppose this channel held the water and inasmuch as the entire grade was fresh and soft from the rains, the road rutted and during the extremely wet weather in November sections of it became practically impassable. If we had placed the sand directly on the subgrade we are certain the conditions would have been better, providing proper crown were given to the road to throw the water to the side ditches. We graded the road to a flat section, the slopes being one to three on the roadside section of the ditch and one and a half to one on the back slope. Our idea was to put the necessary crown in the finished section by using some of the subgrade material plus the sand. A sand-clay road should have a little more crown than the ordinary gravel road and unless this is done, the water is bound to soak into the surface rather than run off.

During the month of December after the ground was frozen sufficiently to carry heavy trucks with loads, we completed the surfacing of a half mile that had been channeled before the cold weather came. After this was completed we surfaced the remainder of the road with sand without channeling. It was possible to use a grader and smooth the sand especially on days when there was sufficient sun to soften the surface. This would not have been possible with gravel but with the sand the grader was able to cut a half inch or more at a time and the result has been that the entire section of road has been in a good passable condition throughout the winter.

Maintenance.—Next spring we propose to put a heavy grader and tractor over the road as soon as the frost has gone and the ground is in a settled condition, and shape the surface

after which we plan regular maintenance work the same as is used on any gravel road. We have already learned that in some places much more sand is required than in others. There were a very few places where the subgrade contained a larger percentage of fine material so that less sand was needed, however, the entire road might be considered as a heavy clay road and an amount of sand varying from 2 to 6 in. in depth was spread over a width of 16 ft. We also plan to maintain this road with sand at least for one or two years during which time the traffic probably will not exceed an average of 300 vehicles per day. After the second year a fourth section of this road will be opened to the west side of the county which will allow traffic from the northwest part of the county to travel easterly to the county line and into Plymouth and Detroit without passing through Arbor and Ypsilanti. When the traffic has increased to 500 or 600 vehicles per day, we plan to use gravel for maintenance.

Costs.—In estimating the cost of building this road as sand-clay instead of gravel we took into consideration the cost of loading and hauling the sand and also allowed a cost of 10 ct. for the material which should be considered the same as would the gravel. The sand used is washed from the gravel at the county washing plant and the allowance of 10 ct. per yard is to cover the payment we make for the material removed from the pit regardless of whether it is sand, gravel or stone. The loading was all done with a steam shovel and cost approximately 10 ct. per cubic yard. We of course, have to meet the argument that it would cost no more to haul gravel than it would to haul the sand, which is true, however, we can build a sand-clay surface for a light traffic for much less than it would cost to build a gravel road because a much smaller quantity of sand is used per mile than could be used if gravel were the metal. We used approximately 861 cu. yd. of sand on the first section and roughly 800 cu. yd. on the other section, and if we assume an average of 900 cu. yd. per mile it means a saving in immediate expenditure of about $2,000 per mile.

Study of Flow in Culverts.—The report of the investigation on the flow of water through pipe and box culverts, conducted during the past four years by the State University of Iowa in cooperation with the U. S. Bureau of Public Roads, has been completed and is now being printed by the State University of Iowa. Included in the tests were concrete, vitrified clay and corrugated metal pipe culverts ranging from 12 to 30 in. in diameter, and concrete box culverts in the following sizes: 2 ft. by 2 ft., 3 ft. by 3 ft., 4 ft. by 4 ft., and 4 ft. by 3 ft.

New Curb and Gutter Forms

A new curb, and curb and gutter form, the outstanding feature of which is the method of locking the bottom of the side rail and dividing plate together as well as the top, and the method of holding the front curb form in place, has been placed on the market recently by the Zeiser Form Co., Endicott, N. Y. The side rails consist of the best open hearth 12 ga. steel channels. The standard lengths are 10 ft. with top and bottom flanges 2 in. wide. Both flanges are slotted to receive the dividing plates at intervals of 5 ft. and may be used either side up—thus eliminating the necessity of pairing them into rights and lefts. End joints are of the tongue and socket type. For the front of the curb form cypress wood

How Dividing Plates Are Lifted Without Using Hooks

1¾ in. thick is advocated. The front curb form is held in position by a U-shaped clamp. The dividing plates for curb, and curb and gutter forms are made of 8 ga. open hearth steel and are accurately shaped to conform with the dimensions desired. Both curb and curb and gutter forms are equipped with an automatic locking device, which holds the bottom of rails as well as the top, firmly in position against the dividing plate. The plate is simply dropped in position between the rail and it is locked. By pressing outward on the top of locking lever the dividing plate is loosened and can be lifted up far enough to pick it out with the fingers. No hooks are necessary. The locking levers are detached from the rails—have no mechanism whatever to get out of order, and are easily picked out after dividing plates are removed, and before taking up the siderail.

Accidents at Grade Crossings.—During the 7-year period 1917-1923. As a result of accidents at highway railroad crossings, there was a yearly average of 1,882 deaths and 5,100 injuries. During 1924 there were 2,149 persons killed and 6,525 injured.

Road Bulding in New Mexico

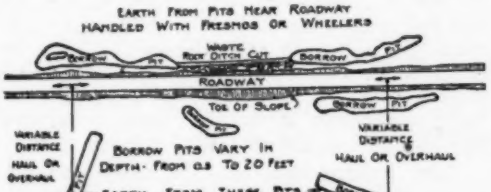
How Construction Methods Are Varied to Meet Local Conditions Described in New Mexico Highway Journal

By H. H. ROBINS
Project Engineer

In highway construction over various sections of the state, many different conditions are encountered, and in order to obtain the best results with minimum expense, standard methods must, in some cases, be replaced by some scheme of construction which will fit local conditions.

In the location and design of the project, the matter of quantities involved should receive considerable attention and the grade line should be laid with due regard for the soil characteristics and the construction methods likely to be used.

Construction in Sandy Country.—In some localities through sandy country, the top layer of sand must be wasted and the subgrade built from satisfactory material, which may usually be found at varying depths below the sand. In other places long sections of the project will be over comparatively level country with rocky material at or near the surface. Under this latter condition the standard for the subgrade, with material from side ditch excavation forming the subgrade proper, is decidedly

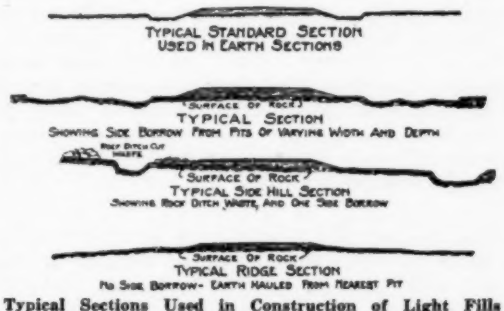

EARTH FROM PITS NEAR ROADWAY HANDLED WITH FRESNOS OR WHEELERS
ROADWAY
TOE OF SLOPE
VARIABLE DISTANCE HAUL OR OVERHAUL
BORROW PITS VARY IN DEPTH. FROM 0.5 TO 20 FEET
VARIABLE DISTANCE HAUL OR OVERHAUL
EARTH FROM THESE PITS LOADED BY ELEVATING GRADER ON DUMP WAGONS, AND HAULED TO ROADWAY

Sketch Showing Conditions Encountered in Making Class I Borrow for Light Fills Over Rocky Country

impracticable. Very light fills are used in this construction and a large percentage of the material excavated from the side ditches is of such size that it cannot be properly incorporated into the fill; hence must be wasted. In many instances, side ditches are unnecessary, there being very little drainage water developed from the flat country.

These features, together with the high cost of this type of shallow rock excavation, make some other method of construction advisable.

Subgrades Built from Soil Pockets.—Over most of the rocky country, pockets of soil of varying sizes and depths are found, and very satisfactory results have been obtained by building the subgrade from material hauled in from these soil pockets. After the location survey has been made, a "soil survey," showing the location of all soil pockets of workable size and depth, is made. The results of this


TYPICAL STANDARD SECTION USED IN EARTH SECTIONS
TYPICAL SECTION
SHOWING SIDE BORROW FROM PITS OF VARYING WIDTH AND DEPTH
SURFACE OF ROCK
TYPICAL SIDE HILL SECTION
SHOWING ROCK DITCH WASTE, AND ONE SIDE BORROW
SURFACE OF ROCK
TYPICAL RIDGE SECTION
NO SIDE BORROW- EARTH HAULED FROM NEAREST PIT

Typical Sections Used in Construction of Light Fills Over Rocky Country From Class I Borrow

survey, when plotted, show the rocky sections where embankments must be formed from outside borrow and the points from which the borrow may be obtained. Some of these soil pockets will be located close enough to the project that fresnos or wheelers may be used to handle the material, while in other sections the material must be hauled in wagons on account of distances.

Overhaul may be figured from the soil survey, the various borrow pits being plotted in their relative location to the center line.

The borrow pits resulting from this type of construction are of every shape, size and depth, as shown by the accompanying sketches, and any attempt to arrive at the quantity of material obtained from them by cross-sections is not worth its cost, the work being slow and laborious and the results very indefinite.

Figuring Quantities from Borrow Pits.—The conditions as outlined above occur, to some extent, on practically every project constructed, at least as far as the shape of the borrow pits is concerned, and in arriving at the quantities involved, it is believed that one of the following methods of procedure should be used:

A. In sections involving both cut and fill, where excavated material may be used in embankment, excavation should be paid for as shown by the neat lines of the section, and necessary borrow should be paid for as the difference between excavation yardage and the fill yardage as shown by neat lines of section, plus 15 per cent for shrinkage. Where Class 3 Excavation is encountered, a correction should be applied for swell.

B. In sections involving 100 per cent fill, from outside borrow, the pay quantity should be as shown by the neat lines of the section, plus 15 per cent for shrinkage.

In the construction of Federal Aid Projects 69 and 70, the impracticability of standard methods of construction, using ditch excavation quantities to build embankment sections, was clearly demonstrated, much grief having been experienced by the men on the job trying to build in 6 in. fills with rock up to 1 ft. or more in diameter. These two projects were finally completed by using the method herein outlined, and in the construction of Projects 30, A, B and C, this method was used throughout with very satisfactory results to all parties concerned.

The question of right-of-way for the outside borrow pits may be raised, and it may be answered by stating that in localities where the rocky or candy conditions prevail the land is of value only for grazing and the acreage of grass destroyed by the borrow pits lying outside of the standard right-of-way is taken care of by the county, as a part of the right-of-way settlements made with the property owners.

On Projects 30-A and B, a nominal amount was fixed as grass damage, but on 30-C all pit right-of-way was donated by the property owners along with the regular right-of-way for the roadway.

In the construction of any project a few sections will occur where conditions are ideal for the measurement of borrow in original position, but ordinarily the reverse is true, and it is believed that with the neat lines of the desired section governing the pay quantities, more satisfactory results will be obtained than would be possible by trying to arrive at borrow quantities from measurements of completed borrow pits.

Form for Integral Curb

An exceptionally light, simple and efficient integral curb form used last year on work at Des Plaines, Ill., is described as follows in Concrete Highway Magazine:

The form is 10 or 12 ft. long and consists of two timbers fastened the correct distance apart by wooden strips nailed on at intervals of about 3 ft. The size of the timbers depends upon the height of the curb. On the Des Plaines work the face form was a four by six, cut to the proper shape, and the back form a four by four. These were trimmed down to make a curb height of three in. which is one of many kinds of so-called suburban curb which are so popular in many communities.

In building the curb the pavement forms are set to come flush with the top of the pavement slab, just as though no curb were to be built. Then the pavement is struck off and partly finished and the curb form is laid in place, so that it rests both on the pavement form and on the concrete slab. It is clamped

Form for Integral Curb

to the pavement form with screw clamps and is filled with concrete which is brought back from the mixer in wheelbarrows. After the concrete has been tamped and spaded, to insure a bond with the pavement and a surface free from honeycomb spots, the form is removed and the curb is finished with a hand float.

Such a form can only be used when the pavement form has an edge on which the clamps can catch, as most shapes of steel rails have. It is especially useful where pavement is being laid upgrade, for any excess moisture brought to the surface in finishing is worked off the slab before the curb form is set, while with the ordinary highbacked form the water must run back along the unhardened gutter.

Annual Meeting of Highway Research Board.—Preliminary plans are well advanced for the 6th annual meeting of the Highway Research Board, National Research Council, which will be held in the National Academy of Sciences-National Research Council building at Washington, D. C., on Dec. 2 and 3, 1926.

Virginia Demonstration Road

Important Highway Investigations to Be Carried Out, Outlined in August Public Roads

By C. A. HOGENTOGLER
Highway Engineer, U. S. Bureau of Public Roads

A demonstration highway from which it is expected to obtain information comparable in value and importance with that produced by the Bates Road and Pittsburg (Calif.) tests and the experiments of the Bureau of Public Roads at Arlington, Va., is now under construction between Fairfax and Warrenton, Va. The road, which is being built by the Virginia Highway Commission under the direction of Henry G. Shirley, chairman, and C. S. Mullen, chief engineer of the commission, is a Federal-aid project. It traverses the historic Bull Run battlefield and the famous bridge over the run still may be seen by visitors to the demonstration road.

The new demonstration, unlike the previous experimental roads, is not intended as a test of road design or of the relative value of different surfacing materials. The Virginia standard 8-6-8 concrete section, which is used on the major portion of the road, is not in question. Instead, the type of information sought concerns a number of questions not covered by the previous tests and relating principally to the influence of the subgrade, the effect of admixtures of various sorts, of the kind and quantity of reinforcement, of various finishing methods, and other details of construction. In general, the type of information sought concerns the economy of various common practices in concrete construction, especially the various measures employed to prevent cracking and breaking and promote the smoothness of the surface.

Variables to Be Studied.—In its length of 9 miles the road provides opportunity for the study of the effect of the following variables:

1. *The subgrade.*—Seven different types of soil are represented in the natural subgrade and thin courses of stone screenings and both single and double layers of tar paper have been used as coverings in certain sections.

2. *Construction joints and dividing planes.*—Expansion and center joints are used in only one section. Construction joints are placed at noon and at night. Longitudinal dividing planes have been used in two sections, in one of which transverse dividing planes have also been used. These planes of weakness are formed by installation of a patented type of separating strip about 2½ in. deep. With the exception of the section containing both longitudinal and transverse dividing planes, which is laid to a uniform thickness of 7 in., the Virginia design of 8-6-8 pavement, 18 feet wide, was used in all sections.

3. *Aggregate, cement, and mix.*—The same sand and crushed stone are used throughout the work. Two well-known brands of cement have been used, and the mix is either 1:2½:3½ or 1:2:4.

4. *Admixtures.*—The three mixtures used are hydrated lime, 5 and 8 per cent; Celite, 3 per cent; and calcium chloride, 2 per cent; all incorporated.

5. *Types of construction.*—The three types of construction employed are plain concrete, vibrolithic concrete, and reinforced concrete. Both single and double layers of welded steel fabric, bar mats, and expanded metal are used in the latter.

6. *Finishing and curing.*—Part of the road is being finished by hand methods. The remainder is to be machine finished, using both Ord and Lakewood finishing machines. With the exception of the section containing calcium chloride, all sections are to be cured alike by covering with wet earth for 14 days.

Experimental work.—The road on which the demonstration is being conducted is strictly a service highway constructed under state supervision with convict labor. It will not be subjected to accelerated traffic.

The Bureau of Public Roads is cooperating in the experimental work, which includes studies of the subgrade, the concrete materials, and the effect of construction operations. The nature of the investigations is briefly as follows:

1. *Material investigation.*—The work, which is carried on at the Arlington Experimental Farm, includes tests of specimens in which either the sand, cement, or stone is varied, and tests, at various ages, of beams made of the same mixes and containing the same admixtures as the road sections. Routine tests and special expansion and contraction observations are being made in the Washington laboratories of the bureau.

2. *Test cylinders.*—Test cylinders made during construction are being cured alongside of the road under conditions as nearly as possible identical with the road slab. The position of batches from which the cylinders are made is marked so that the cores can be drilled later. This will allow a definite comparison to be made between the strengths of cores and cylinders from the same batch.

3. *Surveys and construction observations.*—A complete subgrade survey was made prior to the beginning of construction in the course of which observations of drainage conditions were taken and samples of soil were procured for testing in the laboratory. Subsequent in-

spections of soil conditions have been made after heavy rains.

Observers stationed on the work are keeping accurate records of all occurrences and practices which might influence the condition of the pavement. Atmospheric conditions, temperature and humidity, and the slump of the concrete are recorded hourly. The time of pouring each batch and the time it is finished and covered is kept accurately and the position of the batch is carefully platted with identifying station numbers indicated. This provides an efficiency record which shows the variation in the intervals between the three important stages.

Condition surveys of the surface are made before the wet earth covering is placed and after it is removed; and all of the data mentioned are plotted on final record sheets together with the grade and alignment of the road. Future surveys will be made to determine how the surface condition is influenced by the various factors.

4. *Observations of surface smoothness.*—After the earth covering is removed the relative smoothness of the various sections will be determined by the use of a 16-wheel profilometer. The effect of the surface condition on truck wheel impact will be measured by means of accelerometers attached to trucks; and the effect on the truck body will be measured with a recording roughometer.

Information with regard to the surface smoothness and relative first costs of the various sections will be available immediately. The influence of the various other factors on the condition of the surface can, naturally, be learned only after the road has been in service a sufficient length of time to develop defects.

Water Is Accurately Measured by New System on Pavers

Measurement of water with an accuracy as great as is obtained by weighing apparatus is claimed by the Chain Belt Co., Milwaukee, Wis., for the new pressure water system designed for its 27 E Paver. In addition, the water is gotten into the drum in about 10 seconds with practically no dribble.

The water system consists essentially of a 42 gal. drum-type tank from which the quantity of water delivered is controlled by a siphon at one end which can be rotated about the axis of the tank. When the mouth of the siphon is uncovered and the air breaks the siphonic action, the shape of the siphon is such that all of the water above its mouth is discharged and the flow stops almost immediately. The quantity is therefore dependent on the level of the siphon mouth, which level can be varied by rotating the siphon. This rotation is effected by a rod carried through the end of the tank opposite the outlet and connected with the screw handle apparatus shown in the illustration.

Both shop and field tests covering several months have been made on this system, the latter in conjunction with the Iowa State Highway Department. In the shop tests the tank was so mounted that it could be tilted to compare with its position in a paver operating on 5 and 10 per cent grades and various curve elevations. Testing apparatus was so arranged that the water discharged was weighed directly on platform scales so that a comparison could be made between the theoretical amount of water and the actual amount discharged. In addition, to the tests made with

Water Tank for 27 E Paver

the tank tipped, others were made when it was level, but with the position of the siphon varied by a half turn of the screw handle each time. One turn of the crank was found to equal 0.426 gal. The results indicated that with the tank level the quantities desired can be obtained with 1 lb. An average variation of about 4 lb. was obtained with the tank tipped at various angles, the greater variation being most evident on an "upgrade" position.

Speed was attained by enlarging the discharge from 2½ to 3 in. and straightening it out as much as possible. Reduction of the dribble period was also noteworthy. With a setting of 25 gal. or 208 lb., 192 lb. discharge in 6 sec., while the last 16 lb. required only 4 sec. more. With the old system used heretofore by the company 25 gal. would be discharged as follows: 166 lb. in 15 sec. and the last 42 lb. in from 30 to 40 seconds more. Elimination of the dribble by the improved siphon is responsible for the accuracy of the new system, according to Charles Ball, chief engineer of the company.

Transverse Testing of Concrete

New Apparatus for Field Tests Described in Paper* Presented at Last Annual Convention of American Concrete Institute

By H. F. CLEMMER and FRED BURGGRAF
Technical Engineer, Solvay Process Co.; Assistant Engineer of Materials, Illinois Highway Division

As a means of comparison between the laboratory specimens used in the study of the compression test, and for field testing for which the compression test is not economical, a transverse testing machine has been developed by the Illinois Highway Testing Laboratory. The beams are supported as cantilevers and an extension arm with a container at the extreme end placed over the free end of the beam. Load is applied by an even flow of shot or water from a separate container equipped with a quick-acting valve. (See Fig. 1.) Calculations include overhang of specimen, extension arm and the weight of shot or water required to cause failure. By this method a uniform application of load is made possible and, further, more than one break may be obtained for a check. Exact coincidence of results is not uncommon with the use of this machine while results on the same specimen rarely vary over small percentages.

Economy of Cantilever Testing Method.—In addition to the accuracy of the cantilever testing method another factor of interest is its great economy. Heretofore, testing of concrete has comprised a series of highly technical methods requiring costly machines and equipment only available in well equipped laboratories. The introduction of the cantilever machine has reduced the cost of equipment and machinery required to a negligible amount, made possible the testing of specimens in the field, and materially increased the accuracy of the test.

The adaptability of this method to field conditions has proven of great value to the Illinois division. Economically, it has become more and more imperative that pavements be put in use as soon after construction as possible and that some means be found of completing pavements during the construction season even though low temperatures exist. The cost of providing and maintaining suitable detours for traffic during construction periods is a very considerable item in any highway construction program not taking into account the enormous cost to the public of using these detours rather than the finished slab. Furthermore, many sections of various routes are left unpaved when, due to adverse weather conditions in the fall of the year, it is not possible to complete the work. This situation has been relieved in several instances by the use of an accelerated curing method closely controlled through field strength tests by the new cantilever method.

In Illinois two accelerated methods have been used to cope with the difficulties already mentioned. These are (1) the use of calcium chloride applied to the surface of the slab as a curing agent or the incorporation of the material in the mix as an admixture, and (2) the use of lumnite cement.

The use of calcium chloride applied on the surface as a curing agent has been found, from field tests made with the cantilever apparatus, to produce proper curing in half the time required by the old methods. However, when it is necessary to open a pavement to traffic as soon as possible or to pour concrete under low temperatures much more satisfactory results may be obtained with the use of calcium chloride as an admixture.

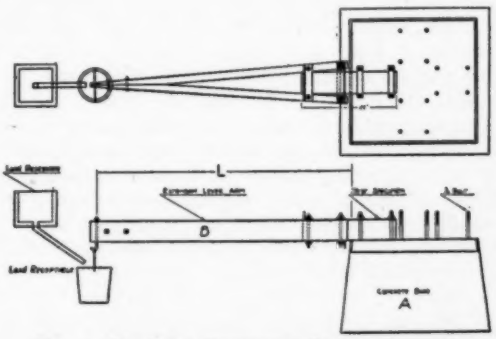


Fig. 1—Cantilever Transverse Testing Apparatus

How the Apparatus Is Used in the Field.—In order to carry on construction with accelerated curing it is necessary to have some method of test which can be easily used in the field to ascertain the strength of the concrete at increasing ages, to determine the intensity of the treatment necessary and finally to indicate when the slab is strong enough to carry traffic. It is particularly important to determine the increase in strength as different brands of cement respond in different degree to calcium chloride as an admixture. Therefore, the success of these methods depends entirely on the correct analysis of the problem in the field and subsequent checking by some accurate field test. For this purpose specimen beams are made in easily constructed forms of the same concrete used in the slab. These specimens are allowed to cure in the

*The paper in full appears in the Proceedings of the Institute Vol. 22, 1926.

same manner as the slab and are broken at regular intervals in a testing machine which for the most part may be constructed on the job. In these field tests the specimens are held in cantilever by being clamped to the rear end of a truck or some nearby structure such as a bridge. The cantilever arm with its load container is then attached to the beam and the load applied. The loading medium generally used is water applied by the mixer hose line, however, dry sand, shot or any free running material may be used. When the results of the tests show the strength of the concrete has increased to that used in the design formula it is definitely known that the pavement may be subjected to traffic without danger of failure. Or, when the concrete is laid during low temperatures it will be definitely ascertained that the proper strength has been gained. Illinois has opened some pavement for traffic in as short a time as 96 hours which would not have been advisable had it not been determined by means of the cantilever testing machine that the concrete had gained sufficient strength to withstand the loads.

It may also be seen that the use of this machine will solve many of the field problems of the materials engineers, for by its use the effect of questionable aggregates, cement, or weather conditions may be easily and accurately determined under the same conditions as the actual construction.

Physical Data on Commercial Building Limestones

From July Technical News Bulletin of U. S. Bureau of Standards.

Limestone is more extensively used as a building material than any other type of natural stone, and the bureau is frequently called upon for up-to-date information concerning the physical properties of the various producing quarries. For the past three years efforts have been concentrated on collecting and testing representative samples from different producing districts to complete the available data and form the basis of a report on this material. The report which is now being compiled will contain considerable information not heretofore available on the greater portion of this product. Properties of stone not generally studied but of considerable interest in a structural way are elasticity, shearing strength, and permeability. Since the usual testing equipment is not well adapted to such determinations on stone it was found necessary to design and construct apparatus for these tests.

For the typical limestones the range in modulus of elasticity results is from 3,300,000 to 5,400,000, while for those very dense limestones approximating the texture of marble this property ranges from 7,000,000 to 11,000,000. Shearing strength for the first group ranges between 800 and 3,000 lbs./in.^{2} and for the second group 3,000 to 4,400 lbs./in.^{2} Permeability results determined on the basis of the quantity of water flowing through a ½-in. thickness of stone 1 sq. ft. in area indicate values varying from 1 cu. ft. per hour for the average limestones.

An investigation is in progress to determine if limestone under considerable stress finally yields by fatigue under a much smaller load than is indicated by ordinary tests. This question has been studied from the point of compressive and bending stresses. Fatigue tests indicated that 60 per cent of the samples rupture in a short time when submitted to a flexural stress equal to 80 per cent of the indicated strength.

Probably the most important tests made were those to determine the relative resistance of the different materials to frost action. A somewhat different procedure was adopted for this purpose, which involved determining the number of freezings and thawings necessary to destroy the different materials. As compared with the usual manner of performing this test the time required was very long, and the process would not be at all feasible for ordinary routine tests. These tests, while intended primarily to compare the weathering qualities of different limestones, are expected to supply the necessary data to enable one to judge more intelligently the weathering qualities of stone from simpler tests. The less resistant limestones disintegrated in less than 100 freezings, while some of the more resistant grades have passed 2,500 freezings and show only a slight amount of decay. Copies of the official publication giving the results of this work will not be available for distribution to the public for some six or eight months.

Paved Roads Save 2½ Ct. Per Mile on Car Operation.—According to the Service Bulletin of the Iowa Highway Commission salesmen, who are paid for the use of their cars on a mileage basis and who travel all classes of roads, find that the saving on paved roads over that on ordinary earth averages 2½ ct. per mile. Few people keep an accurate account of the cost of their automobile transportation. Traveling salesmen who use cars constantly and particularly those who are paid upon the mileage basis usually keep a somewhat accurate account. A tabulation or summarization of hundreds of these accounts, bears out the expressed opinion that the saving on paved roads is at the approximate rate of 2½ ct. per mile.

Proportioning and Grading Aggregates for Concrete Strength

From August Technical News Bulletin of U. S. Bureau of Standards

The proportioning of materials to obtain a concrete of given strength at the age of 28 days is of considerable importance in design of all concrete structures. The U. S. Bureau of Standards is carrying out an investigation in which a study is being made of the effects on concrete strength produced by variation in (a) the gradation of the coarse aggregate and (b) the ratio of fine to coarse aggregate when the coarse is deficient in certain sizes. To obtain data from typical aggregates, river sand is combined with three coarse aggregates, gravel, crushed limestone, and crushed slag. Cement ground from three different clinkers is being used with all combinations of the aggregates. Standard 6 to 12 in. strength cylinders are being tested at six ages, 1, 3, 7, and 28 days, 3 months, and 1 year. Three proportions, 1:1½:3, 1:2:4, and 1:3:6, are being used with the different aggregates.

In these tests the aim is to obtain the same degree of consistency as judged by experienced operators and measured by means of the flow table and slump cone for each aggregate and each mix. To meet this condition it was found that the crushed limestone and crushed slag required more water than the gravel. The concrete in all these tests is mixed to such a consistency that it would be suitable for reinforced concrete construction. The investigation is only partially completed, but based on the results so far obtained the following tentative conclusions may be stated:

(a) Relation of Strength to Water-Cement Ratio.—In designing these mixtures 28-day strengths at least equal to

$$\frac{14{,}000}{7x}$$

(where x equals the water-cement ratio by volume) were expected, and the results obtained with one cement show that for this cement the expectation was justified. For the slag concretes all strengths were above the strength curve given by the above equation and only one point fell below for the limestone concrete. For the gravel concrete several points fell below the curve but only slightly.

(b) Amount of Mixing Water and Consistency.—All mixes were made to a consistency of approximately 95 as measured by the flow table. The amount of water required for any one gradation of any one aggregate was the same for all three proportions of mix. Some comparisons of the different cements indicate that there is a slight but persistent difference in the water requirements of the cements. So far this difference has not appeared as strictly proportional to the requirements of the neat cement for "normal consistency."

(c) Proportions and Gradation of Aggregates.—In general, a uniform gradation of the coarse aggregates gave relatively high strengths. It appears safe to follow in the design of concrete mixes the criterion that sand should be at least one-third of the total aggregate and that gradation of the coarse aggregate should be such that the percentage passing some one sieve and retained on the next smaller sieve be not less than one-third of that retained on the former sieve and passing the next larger sieve.

When the laboratory work of this investigation is completed the results will be studied further and the data and conclusion prepared for publication.

To Have Charge of Earth Roads Investigation

Announcement is made by Charles M. Upham, Director, Highway Research Board of the National Research Council, that C. N. Conner, formerly State Construction Engineer, North Carolina Highway Commission, and more recently Chief Engineer, Mexican National Highway Commission, has been designated chairman of the Earth Roads Investigation being conducted under the auspices of the Highway Research Board. Mr. Conner will give full time to this work continuing the investigation of intermediate type road treatments and experiments from the preliminary stages through which it has thus far been conducted.

Mr. Conner has had a broad engineering experience. After graduating from Tufts College in 1908 he was for two years on construction with the New York Central R. R., following which he was for three years Assistant Engineer with the Bureau of Public Works, Philippine Islands. Later he was Assistant Engineer with the War Department and then with the Navy Department.

He then became Assistant Engineer with the Delaware Highway Department during much of its heavy construction work, following which he was for three years State Construction Engineer with the North Carolina Highway Commission and for one year State Construction Engineer and head of the testing and research laboratory of that organization. During the past year he has been Chief Engineer of the Mexican National Highway Commission.

Mr. Conner is a member of a number of technical societies and the author of articles which has appeared in their publications.

Effect of Certain Materials in the Finish Coat of Plaster

From July Technical News Bulletin of U. S. Bureau of Standards.

In February, 1922, there were erected at the bureau 98 panels of plaster, in the finish coat of which were incorporated various materials which were selected as being likely to cause trouble if present. This investigation was sponsored by Committee C-7 on Lime of the American Society for Testing Materials; the panels erected by the Contracting Plasters' National Association; the materials furnished by the National Lime Association; the plaster applied by the Operative Plasters' International Union; and the bureau conducted the necessary laboratory work, furnished the space for the panels, and made the examinations of their condition. A report indicating the procedure employed in the erection of the panels, the ingredients, sizes, and amounts used in the finish coats, and the condition of the panels at the end of 12 months' exposure has already been published.* However, at the end of three years; that is, on March 4, 1925, in order to accelerate, if possible, any hydration effect, the panels were thoroughly soaked and allowed to dry before examination. This treatment seemed to have the desired effect and while there have been slight changes in some of the panels since the application of the water, their condition when last examined, at the end of four years, was not apparently different from that at the end of three years.

The condition of the panels at the end of four years justifies the following statements relative to the materials employed:

Core (ground limestone) and mica, when added in the amount of 10 per cent by weight of the finish cost, have no effect, regardless of size.

Magnesium sulphate and sodium chloride cause efflorescence.

Iron carbonate, iron sulphide (pyrite), and lime burned during hydration tend to cause unsoundness, but not seriously if fine.

Overburned lime will always give trouble, regardless of size.

Tannic acid is deleterious for special reasons.

Two of the hydrates submitted were found to be unsound.

As stated previously, there have been some changes in the condition of the panels during the second, third, and fourth years. However, it is not believed that these have been sufficient to justify any changes in the recommended basis for a specification for the soundness of hydrated lime, which is repeated for emphasis:

"Examine microscopically to insure the absence of calcium oxide (index of refraction= 1.81).

"Wash the sample through a No. 50 sieve. Dry and weigh the residue and figure it as per cent of the sample. If the residue is more than 5 per cent, it should be analyzed. If this is found to contain less than 90 per cent calcium carbonate, the shipment represented by the sample should be rejected.

"Pyrite can hardly occur in lime, but may be a constituent of the sand. A specification for sand is required, which should also carry limits on the quantity of salt and organic matter permissible."

*Emley and Berger, J. Am. Ceramic Soc., vol. 6, No. 9, p. 1007; 1923.

Shoulder Protection with Creeping Bent Grass

Experiments are being conducted by the Maintenance Division of the Minnesota State Highway Department in the use of creeping bent grass as a means for protecting road shoulders and preventing deterioration of graded highways.

Creeping bent is said to form a mat of grass so thick that it will kill all other vegetation. The grass is propagated by scattering clippings and harrowing them into the top soil. In a few weeks, it is stated, there will be a growth of short grass as dense as a cocoa door mat. This is expected not only to prevent washouts on the highway shoulders but to eliminate the expense of mowing grass and weeds.

A single shoot of the bent grass, if it takes root, is said to develop a mat 3 or 4 ft. in diameter in the course of one summer, and a sq. yd. of sod when shredded with furnish the foundation for a good-sized lawn.

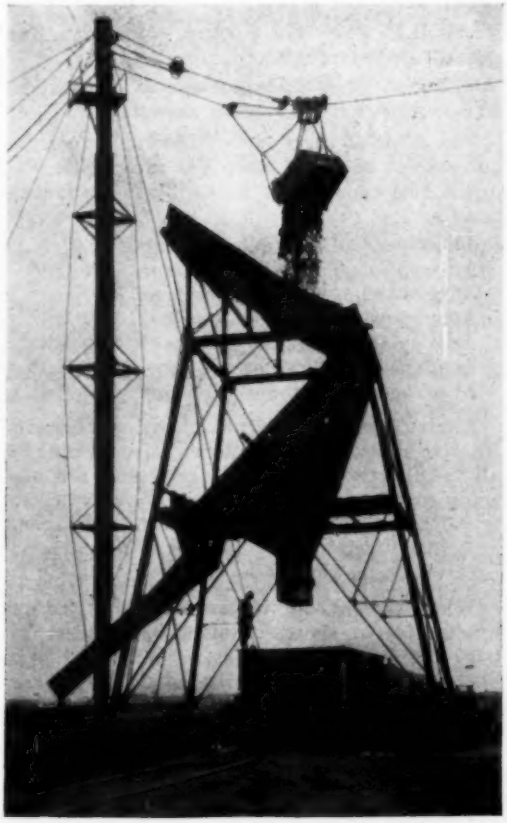
The danger of introducing a pest worse than quack grass was considered before any plantings were made by the Minnesota Highway Department, but it was ascertained that, unlike quack grass, creeping bent is quickly killed by cultivation. The annual plowing will destroy any of the bent grass that may have strayed into nearby fields.

Service Truck for Motor Vehicle Test.—A service truck equipped as a traveling branch office of the Division of Motor Vehicles has been fitted up for that department by the headquarters shop of the Highway Commission of California. The truck is equipped to test headlights, weigh an overloaded truck, issue license plates, explain the kinks of the motor vehicle laws to a perplexed farmer, or do anything else coming within the scope of motor vehicle acts. It is making trips through various sections of the state.

Movable Hopper for Loading Pit Run Gravel

Practical Car Loading Arrangement Used by Missouri Producer Described in Sauerman News

A hopper carried on four car trucks has simplified the loading of pit run gravel at the pit of the Howell Gravel Co., La Grange, Mo. The company is working a deposit of 100 acres of gravel which seems to be the site of an



Car Loading Arrangement Used by Howell Gravel Co., La Grange, Mo., for Handling Pit Run Gravel

abandoned river channel. The material has a depth of 10 to 30 ft., with a clay overburden just about sufficient to supply the 10 per cent of binder which the highway specifications call for, so that no stripping is necessary, as all the material goes into highway work.

The deposit is fairly well graded and meets the requirements just as it comes from the pit, except that it is dropped onto a grizzly to take out a small amount of oversize. This process has the added advantage of breaking up the clay and getting it more thoroughly mixed with the gravel.

In 1924, W. F. Howell, installed a 700-ft. span Sauerman slackline cableway excavator with bucket of 2 cu. yd. capacity, operated by a Sauerman two-speed steam hoist. When recently visited, it was found that the cableway had excavated a pit 600x1,400 ft. in size on one side of the railroad track, and this season the span has been shifted around so that the excavator is now digging on the opposite side of the track.

By means of the movable track hopper, it is possible to follow easily the movement of the cableway as it shifts position to cover a new portion of the deposit. That full advantage has been taken of this feature is shown by the fact that the deposit has been worked to a length of 1,400 ft. along the track, and now the performance is to be repeated on the other side of the track where there is an equally large area for the cableway to span.

The hopper is mounted on a steel frame which straddles the loading track. Each of the four legs of this frame rests on an ordinary car truck, the trucks running on two movable sections of track.

Two grizzlies are mounted above the hopper. The upper one of the pair has its bars spaced sufficiently far apart to allow all the material to go through. Its principal function is to assist in the mixing of the clay into the gravel. Incidentally it serves to ease the fall of the material and put less strain upon the structure. The second grizzly takes out the large stone, which falls through a chute into a wagon which is kept in position to receive it, as this stone is either sold or is used as needed about the place.

The hopper and supporting frame were made for the plant at a steel fabricating plant. The cableway mast is a 90-ft. built-up timber mast of standard Sauerman design.

$100,000,000 for Australian Roads.—The Commonwealth Government of Australia is considering an appropriation of $100,000,000 for the construction of main roads. The proposals, if agreed to, will only come into operation in the next financial year, and no money has as yet been made available for the scheme, which has yet to be made the subject of an agreement between the Commonwealth and the State Governments ratified by the State Parliaments.

The scheme provides for a sum of $10,000,000 per annum to be voted from revenue for road purposes, the amount to be distributed among the different States on a basis of three-fifths population and two-fifths area on dollar for dollar basis, the States providing their contributions out of loan or revenue.

Road Test Truck

New Test Vehicle of North Carolina Highway Commission Described in Highway Research News

By H. B. SHAW
Director, Engineering Experiment Station,
North Carolina State College

In their road-test truck, the North Carolina State Highway Commission and the Engineering Experiment Station of North Carolina State College have a valuable device for measuring the power required to drive motor vehicles on all sorts and conditions of roads.

The unique feature of this test vehicle may be stated briefly as follows:

1. It has an electric drive superimposed upon the usual mechanical drive.

2. The motors are series wound, of the railway or battery vehicle type. The electric generator also is "series wound," which is unusual.

3. Instantaneous and average values of speed and of the electric current in the single main circuit are determined independently. From them, the power delivered to the vehicle mechanism is easily calculated.

4. The road test truck, at specific speeds, measures the average power instead of the tractive resistance. The latter, however, may be calculated from the power, speed, and mechanical efficiency.

5. The vehicle contains a specially constructed "antivibration" suspension for the graphic instruments, voiding the effects of the vehicle vibrations, tilts, and jars.

6. An ampere-hour meter and the elapsed time are used to get the average value of the electric current for a run, instead of averaging the current from the charts of the recording ammeter. This saves much time.

The test vehicle is operated at a selected speed which, for accurate measurements, must be kept constant during a run. It requires some practice to keep the speed constant by manipulation of the throttle of the gasoline engine. The speed commonly used for test runs is 15 miles per hour, though tests have been made at speeds as low as 2 miles per hour and as high as 30 miles per hour.

A feature of this electric drive is that it does not retard the vehicle motion downhill nor will the vehicle measure the power when none is required, as when coasting. Consequently, the brakes have to be used to hold the speed constant on down grades of any consequence.

The vehicle will measure the power at different speeds on hilly roads, the power to pull through mud, sand, etc. To get the comparative horsepower on different road surfaces it is preferable to select fairly level roads and avoid the necessity of calculating and eliminating the effect of grades.

A large number of test runs on a race track showed, at 15 miles per hour, the following results:

10.30 H.P. when the surface was wet and muddy.

9.30 H.P. when the surface was partially dried.

8.50 H.P. when the surface was nearly dry and somewhat rough.

5.17 H.P. when the surface was in the best of condition, dry and fairly smooth.

The effect of the speed of the truck upon the horsepower required when the race track was in the best condition is shown by the following results:

At a speed of 2½ miles per hour, 0.67 H.P.
At a speed of 5 miles per hour, 1.40 H.P.
At a speed of 10 miles per hour, 3.10 H.P.
At a speed of 15 miles per hour, 5.17 H.P.
At a speed of 20 miles per hour, 8.10 H.P.
At a speed of 25 miles per hour, 12.45 H.P.
At a speed of 30 miles per hour, 19.00 H.P.

Analysis of the internal losses, analysis of tractive resistance, recalibration, and study of all the functioning of the test vehicle are now being made. The measurements are sufficiently delicate to permit very accurate adjustment of brakes, tests of the effect of different lubricants upon power losses, etc.

When the present laboratory investigations are completed, the test runs are to be resumed and continued for at least a year in order to get all-year, all-weather comparative horsepower for different road surfaces.

The further intention is to use the comparative horsepower as a basis for getting the difference in mileage costs for gasoline, tires, and maintenance resulting from operation on different road surfaces. Neglecting other savings in cost due to hard-surfaced roads, the differences in cost per ton-mile for tires, gasoline, and maintenance can be taken as the difference in cost per ton-mile for different road surfaces, and used to determine the economy of highways.

The results are expected to demonstrate quantitatively the volume of traffic at which expenditures for first-class highways are economically justified, through saving more in the cost of vehicle operation than the additional annual cost of the improved highway.

New Diesel Engine for Industrial Field

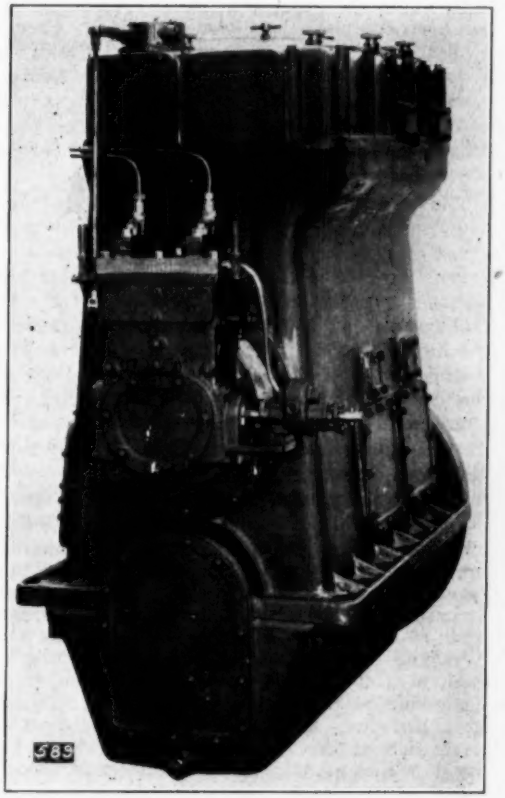
A diesel engine with many new and distinctive features, designed to meet the specific requirements of the industrial field, has been brought out by The Foos Gas Engine Co., Springfield, O. While completely enclosed, the new engine is yet accessible. Large cover plates are provided on both sides, opposite the crank throws, which gives access to the lower part of the main cylinder frame. The top of the engine is provided with cover plates for inspection of the heads, the valves, and the valve mechanism.

The Foos industrial diesel follows in considerable detail the practices that have been followed in the construction of other Foos units. It is a 4-cycle engine and operates on the full-diesel combustion cycle. A cross section of the engine indicates a plain diesel combustion chamber; in other words, the head is perfectly flat, there being no recesses or precombustion cups of any type. Fuel for combustion is injected into the combustion chamber, vertically, at the axis of the cylinder. Complete atomization of the fuel is secured by the mechanical injection principle that has been successfully used in the case of the large stationary Foos diesel unit.

Four valves are provided in each head, two for exhaust and two for inlet. At the level of the head of the main box frame, which houses the entire unit, a recess in the casting provides the air inlet manifold. Accordingly, the air inlet valves are located in the head adjacent to the front side of the engine. Passageway through the main box frame at the back of the engine is provided for the exhaust gases to enter into an exhaust header. For valve operation, a lay-shaft or cam-shaft runs full length of the engine at the level of the cylinder heads. The cam-shaft drive involves the use of a silent chain driven directly from the crank shaft.

The whole valve arrangement is very simple and accessible. It is arranged that any of the valves or the valve lever proper may be removed without disturbing any other portion of the mechanism. This simplicity, of course, is absolutely essential since the engine will be called upon to operate in the hands of engineers that may not have experience in the operation of diesel units.

Even the flywheel of the new engine is enclosed. All of the fuel pumps and the governor are completely housed, giving them the same protection as is offered the other main working parts of the engine. Lubrication of the engine has been taken care of in a very efficient manner. A central lubricating oil system furnishes oil to every bearing in the engine under pressure. In the lower part of the bed plates a trough is provided where the lubricating oil is collected. An oil pump picks up the lubricant, puts it under pressure and distributes it to all the bearings of the engine. Not a single oil cup or grease cup is found on the unit.



The Foos Industrial Diesel

The new Foos industrial diesel has an operating speed from 400 to 900 RPM. Tests that have been made at the factory on this unit indicate complete combustion is secured throughout this entire range. The design of the sprays and the fuel system as a whole is such as permits the use of low gravity fuel oils. The new engine is to be built in units of several cylinders. Engines of a rating as low as 45 hp. and as high as 475 hp. are possible with the one cylinder size and the established range of speed.

Highway Engineering Endowment for University of Michigan.—The University of Michigan, according to a press report is to be offered an endowment fund of $75,000 to $100,000 a year for the establishment of separate school of highway engineering.

High Arch Bridges on Road Relocation

Relocation of the State highway through the Sacramento canyon in northern Shasta County, California, includes the building of four major bridges, three of which will be of the arch type. One of these, the Charley Creek arch, has been completed; a second, at Doney Creek, is under way, while a third at Dog Creek, is about ready for contract. All three arches span deep canyons where considerable saving in distance is being made with decided improvement in alignment and grade. Reinforced concrete is the material being used.

The new structure at Charley Creek, now open to traffic, saves ½ mile of 6 per cent grade and eliminates seven sharp and dangerous curves. Four approach spans at either end and two 8-ft. pilasters lead up to the central feature, a 147-ft. spandrel arch, at present the highest on the State highway system. The distance from the creek bed to the roadway of the bridge is 120 feet. The total length is 394.5 feet. The following construction details of the bridges are given by W. H. Johnson, Resident Engineer of the Bridge Department, in a recent issue of California Highways.

Charley Creek is a small stream and the flow of water did not interfere with the erection or maintenance of the arch centering. The contractors were successful in designing and constructing a light falsework which was carried up in 20-ft. bents, at 14-ft. centers, 4 in. x 6 in. caps and posts being used. At the bottom of each bent 2 in. x 6 in. scabs were nailed on each side to take up some of the thrust and hold the posts in place. Cables attached to each side of the top of the falsework held it rigid while pouring of concrete was taking place.

In order that no unequal strain would be thrown on any part of the structure, care was taken to pour the fresh concrete to the same elevation at both sides and ends of the arch. The falsework was built to provide for an estimated settlement of 2 in., and when the centering was struck the arch crown was on exactly the plan elevation.

For finishing the structure, a mixture of 1 part of fine sand, 2 parts of cement, and an amount of calcium chloride equal to 5 per cent of the cement was mixed with water and used as a paint on the exterior. After this application had set, which took from a few hours to several days according to weather conditions, the brush coat was dampened and rubbed with a carborundum stone until it lathered and filled the air pockets. It was then brushed out with a wet brush to a smooth surface.

The contractors also took great care to keep the lines true and the forms well tied. There was no bulging of forms. The concrete also tested well. Deck concrete, Class "A" (6 sacks of cement per cubic yard), averaged 3586 lb. per square inch; abutment concrete, Class "B" (5 sacks of cement per cubic yard), averaged 2530 lb. per square inch, while that in arches and columns, Class "F" (7 sacks of cement per cubic yard), averaged 4650 lb. per square inch.

Harlan D. Miller, bridge engineer, had general direction for the state. Bordwell and Zimmerman of Napa were the contractors.

Road Congestion Costs Millions

More than $3,650,000,000 a year is the loss in the United States from inadequate traffic facilities and control, according to the report made in Washington by a committee of the National Conference on Street and Highway Safety, promoted by Secretary Hoover.

As a relief from this condition wider highways are being urged by all the organizations identified with highway traffic, transportation and construction. The adoption of wider highways is pronounced in some states, many roads known as "super-highways" being projected with at least four one-way traffic lanes and sometimes six or eight, with the heavy trucks separated from the lighter automobiles and with better provision for highway safety.

Commercial losses from traffic congestion are becoming serious in the large cities. Records kept by a Philadelphia taxicab company show that its cabs lose on an average of $2.50 a day each because of traffic congestion. The loss in one year represented 9.5 per cent of the working time for a fleet of 836 cabs. Applying half the loss shown by the Philadelphia cabs to the 900,000 automobiles registered in New York City, the committee arrived at an estimate of more than a million dollars a day lost in New York alone. For the entire United States it was conservatively estimated that the loss runs up to an average of $10,000,000 a day. The fuel loss and the wear and tear on cars and trucks due to stopping and starting at street intersections, it is considered, is comparable to the loss in time.

Disposing of Boulders on Road Grading Job.—During the grading of a highway near Waupaca, Wis., a large number of boulders were encountered in one side bank. The contractor was at a loss to know what to do with them, unless he purchased right-of-way to place them on. Finally he dug a trench with his shovel outside of the shoulder line, hauling the material to make the fills. Then the side bank cut was made and the boulders cast into the trench and covered. This method proved very satisfactory.